Dyke's
Automobile and Gasoline Engine Encyclopedia

TENTH EDITION

Containing 532 Charts, Inserts, Dictionary, Index,
and Supplements on the Ford, Packard, Airplanes,
and Liberty "12" Engine.

TREATING ON
THE CONSTRUCTION, OPERATION AND REPAIRING
OF AUTOMOBILES AND GASOLINE ENGINES.
Also Trucks, Tractors, Airplanes, and Motorcycles.

BY
A. L. DYKE, E. E.

ORIGINATOR OF THE FIRST AUTOMOBILE SUPPLY BUSINESS, PUBLISHER OF
THE FIRST PRACTICAL BOOK ON AUTOMOBILES AND MANUFACTURER OF
THE FIRST FLOAT FEED CARBURETOR IN AMERICA.

AUTHOR OF
"DR. DYKE'S DISEASES OF A GASOLINE AUTOMOBILE;"
THE FIRST PRACTICAL BOOK ON AUTOMOBILES IN AMERICA, (1900).
"DR. DYKE'S ANATOMY OF THE AUTOMOBILE," (1904).
"DYKE'S MOTOR MANUAL;" ALL ABOUT MOTORCYCLES, MARINE
ENGINES, MOTOR BOATS, STATIONARY GASOLINE AND OIL ENGINES.

Copyrighted 1911-1912-1913-1914-1915-1916-1917-1918-1919.
By A. L. DYKE, ST. LOUIS, MO.
All Rights Reserved.

Copyright Protected in Great Britain, all of her Colonies and Canada.
Entered at Stationers Hall, London.
Plates made, type set and printed in U. S. A.
All Rights Reserved.

PUBLISHED BY

A. L. DYKE, Publisher

Exporter and Importer

ST. LOUIS, : U. S. A.

For Index—see colored page, 867 in back of book. For Dictionary—see page 861.
For Index to Charts—see first page fly leaf of book.

TABLE OF CONTENTS

Instruction — Pages

1—Automobile Assembly 1- 17
2—The Drive Systems 18- 22
3—Steering Assembly, Springs and Brakes 23- 30
4—Axles, Differential and Bearings.. 31- 36
5—Clutches, Universal Joints........ 37- 44
6—Transmissions 45- 51

ENGINES.

7—General Construction 52- 71
8—Principle. Location of Parts.... 72- 92
9—Valve Timing 93-115
10—Firing Order 116-120
11—Six, Eight and Twelve Cylinder Engines 121-140

CARBURETION.

12—The Carburetor; Principle and Construction 141-165
13—Carburetor Adjustments 166-184

COOLING AND LUBRICATION.

14—Cooling Systems; Radiators, Pumps, Fans 185-194
15—Lubrication. Oils and Greases...195-205

IGNITION; COIL AND BATTERY.

16—Low Tension Systems............206-217
17—High Tension Systems 218-232
18—Spark Plug and Coil Troubles...233-241
19—Modern Battery and Coil Systems.242-254
20—Brief Review of the Various Coil Systems 255

IGNITION; MAGNETOS.

21—Low Tension. (Principle and Construction) 256-267
22—High Tension. (Leading types described) 268-293
23—Installation, Care and Adjustments.294-304
24—Ignition Timing 305-320

ELECTRIC SYSTEMS.

25—Engine Starters 321-322
26—The Electric Starting Motor.....323-331
27—The Generator. (Source of Current) 332-355
28—Types of Starting and Generating Systems used on Leading Cars....356-373
28A-Delco Early Ignition Systems....374-378
28B-Delco Modern Ignition, Starting and Lighting Systems 379-396
28C-Care, Tests and Adjustments of Delco Systems 397-405
29—Care, Tests and Adjustments of Other Leading Systems..........406-424
30—Wiring a Car 425-429
31—Lighting a Car 430-438
32—Storage Batteries 439-455
32A-Storage Battery Repairing..456-475-864D
33—Electric and Gas-Electric Vehicles 476-484

OPERATION, CARE, ETC.

34—Operating a Car 485-500
35—Rules of the Road..............501-504
36—Care of Car 505-510
37—Accessories. Touring 511-520

TABLES, SPECIFICATIONS, ETC.

38—Insurance. License and Laws....521-528
39—The Automobile Salesman........529-533
40—Horse Power Tables and General Data. Standard Adjustments of Leading Cars. Specifications of Leading Cars 534-548

TIRES.

41—Tires. Air Pumps and Compressors.549-564
42—Tire Repairing and Care of......565-575

TROUBLES AND REMEDIES.

43—Digest of Troubles...............576-591

REPAIRING AND ADJUSTING.

44—The Automobile Repairman.......592-595
45—Garage and Shop Equipments....596-619
46—Repairing and Adjusting Engines.620-659
46A-Adjusting Clutches, Transmissions, Rear Axles and Differentials.....660-679
46B-Adjusting Wheels, Brakes and Steering 680-694
46C-How to Use Tools and Make Repairs. Oxy-Acetylene Welding....695-729
46D-Useful Shop Hints and Devices..730-745

MISCELLANEOUS.

47—Commercial Cars 746-752
48—The Tractor 753-754
49—Engines; different principles......755-765
49A-Addenda; Tractors, Truck Engines and Repairs; Governors, Motorcycles, Repairing Tops, etc.......829-849
50—Dictionary of Automobile Terms..861-864

SUPPLEMENTS.

The Ford 766-828-864A
The Packard—"3-25" & "3-35".....850-860
Airplanes 900-922
Wiring Diagrams 923-926
K. W. Magneto Supplement..........928-930
Index 867-898
Liberty Engine Supplement..........933-940

INSERTS.

There are several inserts dealing with Engines, Modern Cars, Dixie Magneto, Motorcycles, etc.

Use the Index—refer to it often. Any trouble you may have, refer to index. See page 543 for Specifications of Leading Cars.

6450361

228715
NOV -5 1919
STQ
.D99
.2

PREFACE

THIS AUTO INSTRUCTION was prepared with the idea of presenting in clear, simple form, the principle upon which gasoline engines and automobiles are built and operated, and to explain in detail all that an operator must understand in order that he may operate and care for any make of car or gasoline engine.

In order that the reader may clearly understand the modern details of an automobile and its parts, it was necessary to illustrate and describe the *early type* of cars and gradually work up to the more modern types. For this reason many of the subjects begin with early models or types, which is absolutely necessary before the reader can properly master the subject.

The reader will learn the principle of construction of the different parts of any automobile in general use. The construction may vary, but the principle remains the same. Consequently when the reader masters the principle involved, he masters the construction of ALL types of automobiles, engines, ignition systems, carburetors, etc.

This system of instruction together with the working models represent the practical result of the writer's intimacy with the industry since its very beginning, as well as matter collected from all available sources in the world.

For many of the illustrations and much information to be found in this book, the writer is indebted to the "Automobile," of New York, "Motor Age" of Chicago, "Automobile Dealer and Repairer," of New York, and "Motor World" of New York, as well as a great number of manufacturers of automobiles and accessories. The writer is also indebted to Mr. P. J. McCullough and Mr. A. W. Rhein for valuable assistance rendered.

The illustrations are not drawn to scale, in fact, the majority of the illustrations are exaggerated in a great many instances—in order to clearly describe the subject treated.

The writer makes no attempt to treat the subject in a theoretical manner, his idea being to adhere strictly to the practical side of the subject.

A. L. DYKE

NOTE:—The reason for using the older model car as shown below and in charts 1 to 10 is for two purposes; (1st) to familiarize the student with the **early** models and gradually work him up to the modern type of car as he progresses. (2nd) to show the relation between the parts. For instance, in the modern type of car, the engine, clutch and transmission are in one unit. It would be more difficult for the student to understand, if these parts were all together. Therefore, as he progresses he is gradually taken from the early model to the modern twelve cylinder car.

Why we use exaggerated illustrations—not drawn to scale—is due to the fact that we have found from experience that exact scale drawings would not explain the subject clearly.

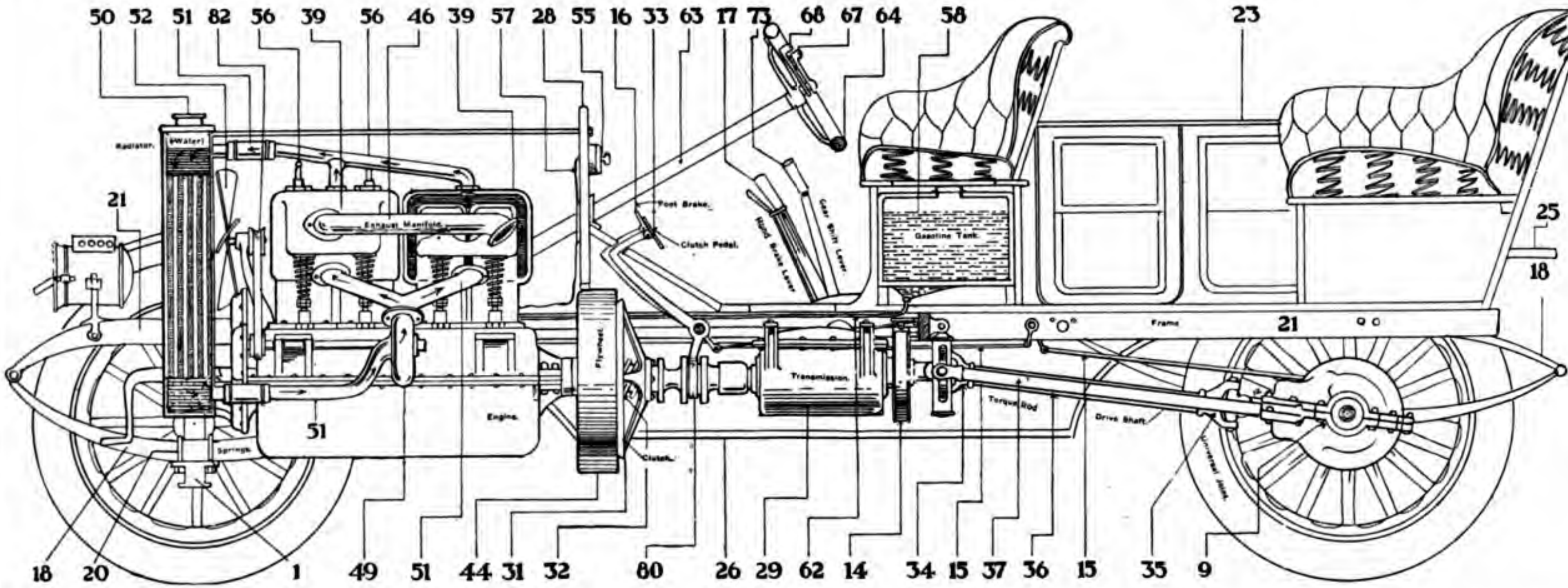


CHART NO. 1—Side sectional view of an automobile touring car. **Motive power**—four cylinder gasoline engine. **Type of clutch**—cone (the single plate clutch is now coming into general use). **Drive**—shaft. **Cylinders**—T head type. **Valves**—intake on one side, exhaust on other. **Cooling**—forced water circulation by pump (fan).

Gasoline feed—gravity (modern method is by vacuum, see page 163). **Transmission**—selective gear type. **Axle**—floating type, revolves inside of housing. The modern method of gear shift—both levers in the center, see page 486.

Improvements: The modern power plant consists of engine, clutch and transmission in one unit or housing (see page 44). The control levers are placed in the center instead of on the side. The gasoline feed system is the vacuum feed type on a majority of cars—all of which are treated further on.

RUNNING GEAR.

Front Axle	1
Steering Knuckle Pivot	2
Steering Knuckle Arm (right)	3
Steering Knuckle Arm (left)	4
Steering Knuckle Tie Rod	5
Steering Gear Connecting Rod	6
Steering Knuckle Gear Rod Arm	7
Rear Axle (Housing)	8
Differential (inside of case)	9
Axle Drive Bevel Gear	10
Axle Drive Bevel Pinion	11
Axle Drive Pinion Shaft	12
Axle shafts are inside of axle housing.	
Brakes on Hub of Wheels (*Operated by Hand Lever)	13
*Brake on Drive Shaft (*Operated by Foot Pedal)	14
Brake Rods	15
Brake Pedal (Running)	16
Brake Lever	17
Springs	18
Spring Blocks or Seats	19
Spring Clips	20
Frame.	
Main Frame	21
Sub-frame	22

BODY

Body	23
Fenders	25
Running Boards	26
Dash	28

TRANSMISSION SYSTEM.

Transmission Gear Box or Gear Set	29
Cover Plate for Transmission	30
Clutch.	
(Cone Type)	31
Clutch Spring	32
Clutch Pedal	33
Drive.	
Universal Joint (forward)	34
Universal Joint (rear)	35
Drive or Propeller Shaft	36
Drive Pinion Shaft	12
Differential Driving Pinien	11
Differential Driving Gear	10
Torque Rod	37

POWER PLANT.

Engine.	
(Four Cylinder) Cylinders Cast in Pairs	39
Inlet Valve Caps	40
Exhaust Valve Caps	41
Crank Case (Split type)	42
Starting Crank	43
Flywheel	44
Inlet Manifold	45
Exhaust Manifold	46
Exhaust Pipe	47
Muffler	48
Cooling System.	
Pump	49
Radiator	50
Cooling Water Inlet and Outlet	51
Fan	52
Fan Belt	82
Ignition System.	
Magneto (High Tension type)	53
Magneto Drive Gear in Engine Gear Case	54
Ignition Switch	55
Spark Plugs	56
Cables (High Tension Ignition)	57
Fuel System.	
Fuel Tank	58
Inlet Manifold	45
Carburetor	60
Throttle on Carburetor	61
Fuel or Gasoline Pipe	62

CONTROL SYSTEM.

Steering Post Assembly.	
Steering Column Tube	63
Steering Gear Case	81
Steering Wheel	64
Steering Gear Arm	65
Spark Hand Lever	67
Steering Gear Connecting Rod	6
Throttle Hand Lever	68
Spark and Throttle Sector	70
Spark and Throttle Control Rod	71
Throttle Lever Shift Rod	72
Hand Lever Assembly.	
Gear Shift Lever	73
Brake Lever	17
Gear Shift Gate or Selector	76
Gear Shift Lever Shaft	77
Pedal Assembly.	
Clutch Pedal	33
Brake Pedal	16
Clutch and Brake Pedal Shafts	78
Clutch Release Fork	80

*Modern practice is to have **Hand Lever** operate the external brakes and **Foot Lever** the internal brakes—both on rear wheels.

CHART NO. 2—Key to Motor Car Parts; illustrated in Charts 1, 3, 4, 5, 6, 7, 8, 9, 10. 31 and 32.

Note: Modern type of cars will be shown further on in this book. Read heading top of page IV.

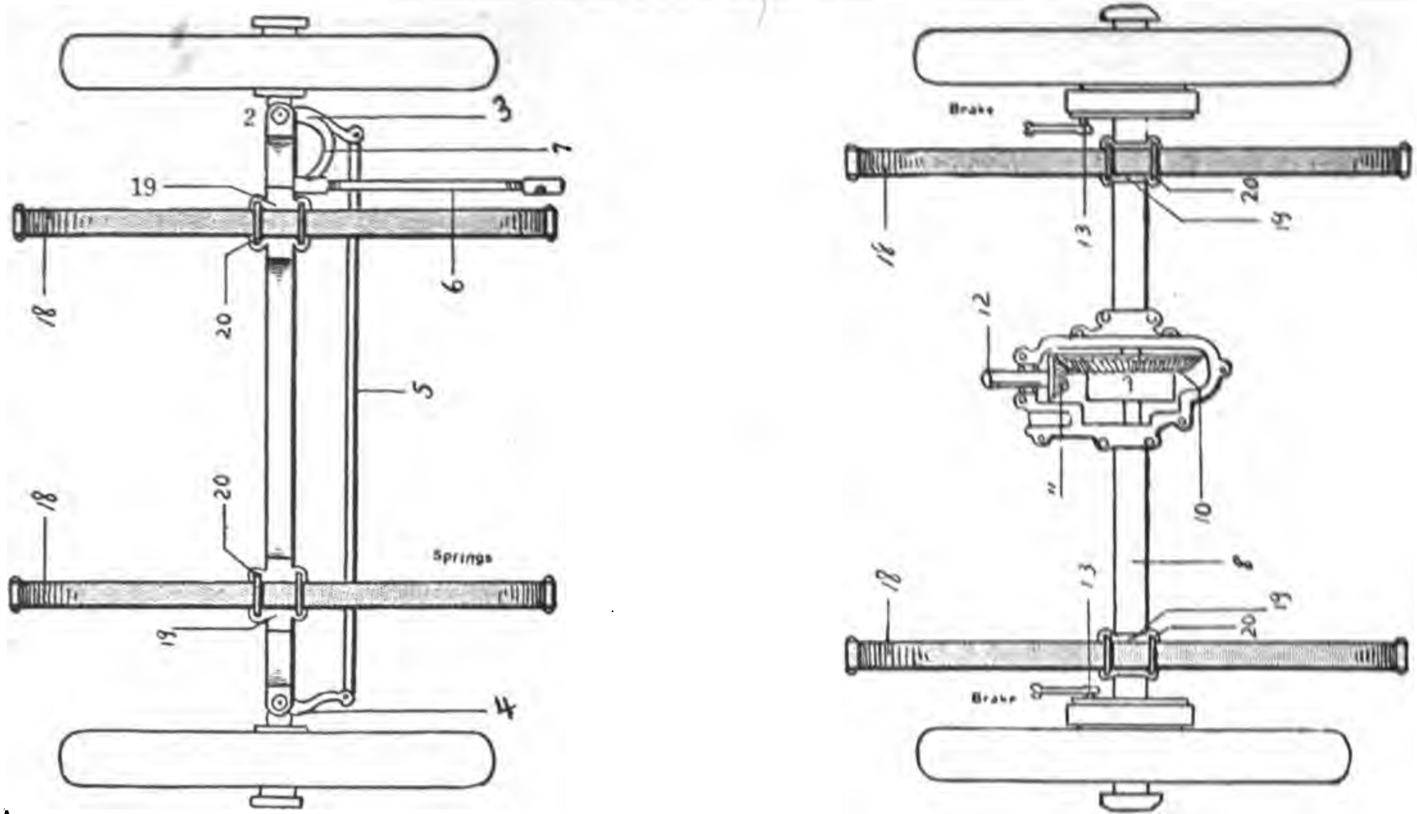


CHART NO. 8—Wheels, Rear Axle, Front Axle and Springs.

In building up a car the first parts to begin with are the **front and rear axles** (*see chart 17, page 32, for the different types). The above illustration shows the **brakes** on the hubs of the rear wheels, (see chart 16).

The **differential** (9) (see chart 18, page 34), housed in the **differential gear case**. The **drive pinion** (11) is shown. Other types of drive gears used in the differential are spiral gears and worm gears, pages 21 & 35. The last mentioned are used more on trucks.

The **steering knuckle tie rod** (5) is shown connected from the **steering knuckle arms** (3 and 4) and the **steering gear connecting rod** (6) is shown connected to the **steering knuckle gear rod arm** (7).

The **springs** (18) are next mounted on the **spring seats** (19) on the front and rear axles, and are rigidly connected by means of **spring clips** (20).

For the various types of springs, see chart 15, page 26.

---

*NOTE—The above rear axle is the propeller shaft driven axle. Solid rear axles are usually used on trucks, with differential mounted on frame with transmission (see charts 11 & 18, pages 14 and 20). Auto Builders usually purchase these parts from part manufacturers who specialize in these various products.

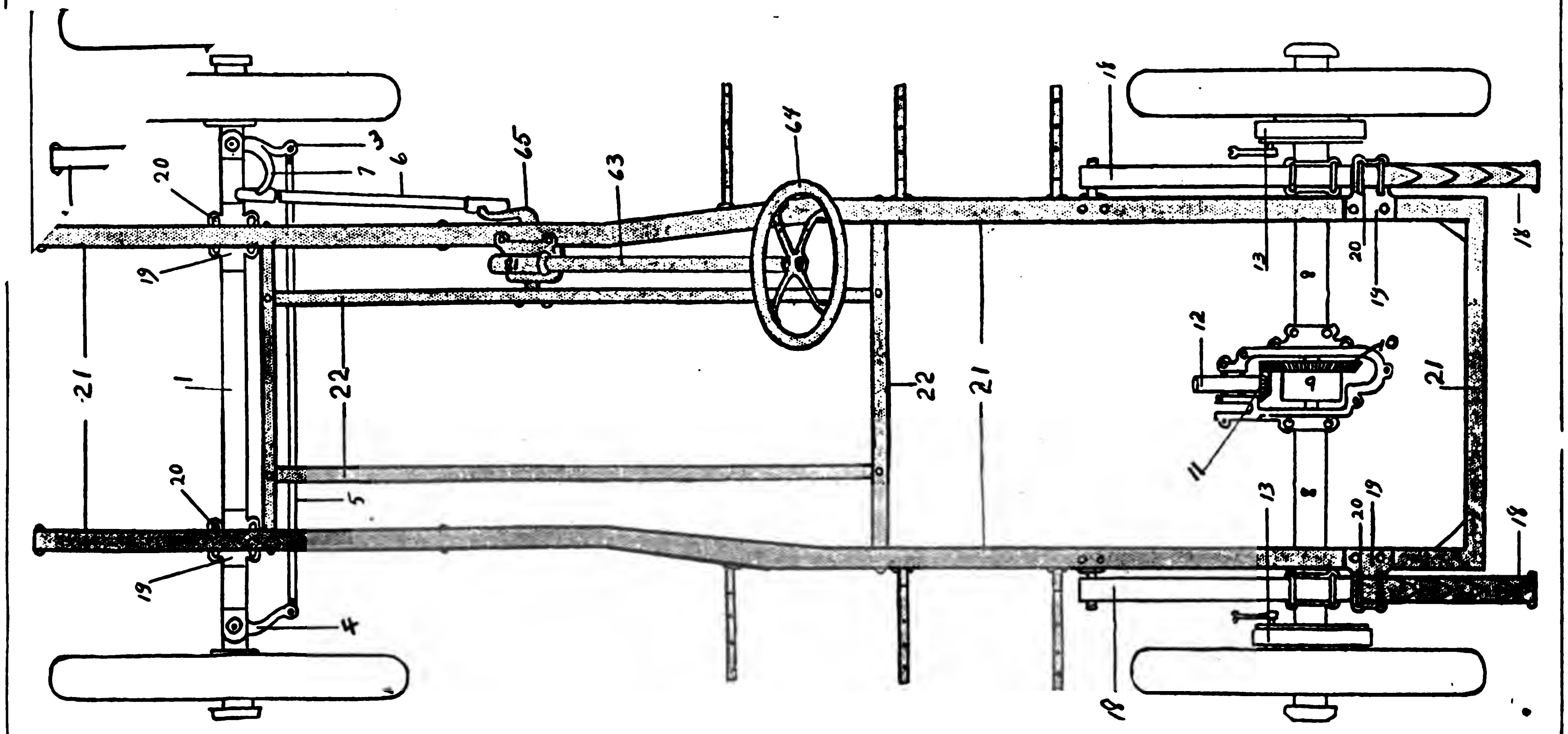


CHART NO. 4—THE RUNNING GEAR is Completed when the Main Frame and Sub Frame for supporting the Engine and Steering Device are added.

We now complete the **running gear** or **foundation** of the **car**, by adding the **pressed steel frame** (21) and **sub frame** (22).

The sub frame supports the power plant. Sometimes the sub frame is omitted when engine and transmission are equipped with supporting ears or lugs (which is now common practice). When so equipped, attachment is made to the main frame direct.

The **steering device** (see chart 14, page 24) is bolted to the frame and the **steering gear arm** (65) is connected with the **steering gear connecting rod.**

It will also be observed that the **brackets** for supporting the running board are attached to the side of the frame. We are now ready for the **power plant.**

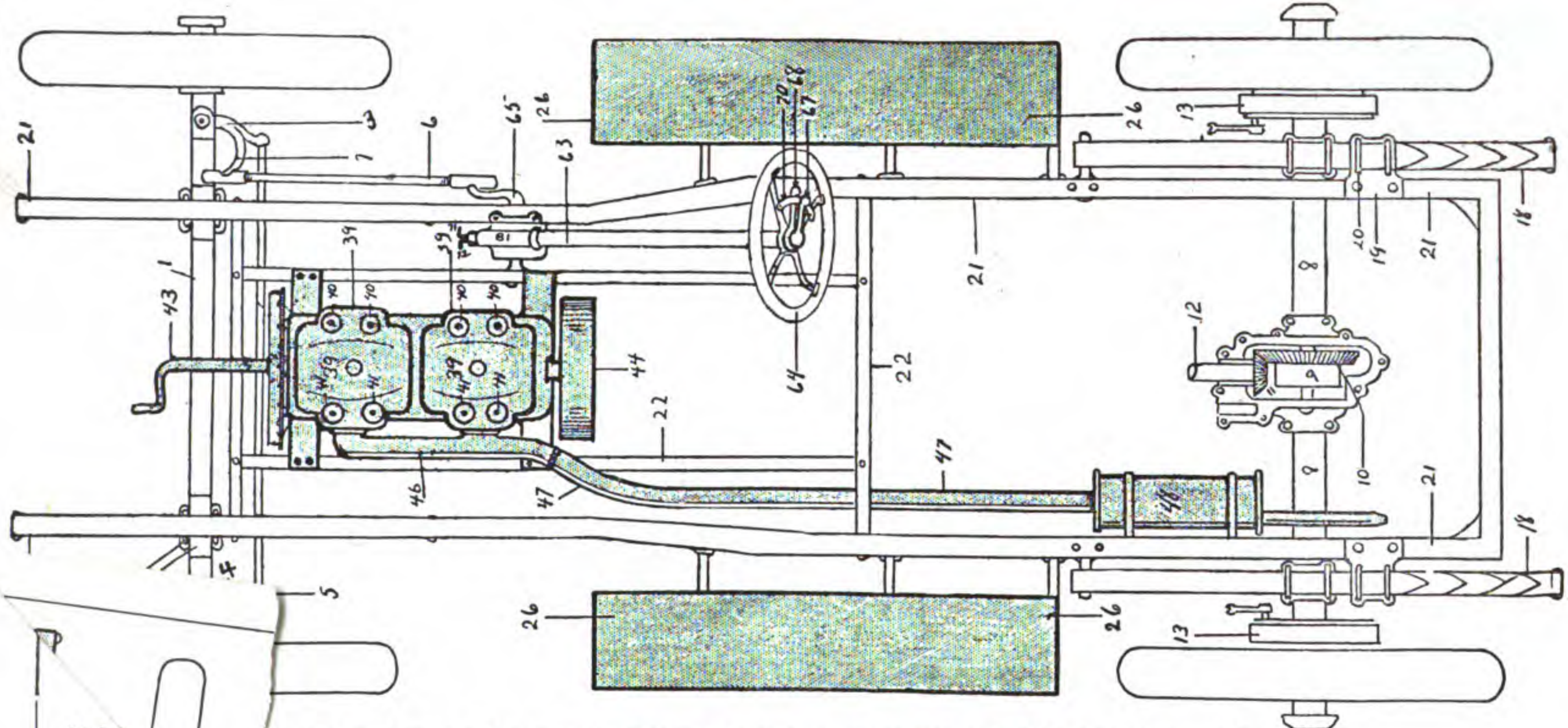


CHART NO. 5—THE POWER PLANT: the Engine, Exhaust Pipe and Muffler are now added.

In bu
axles (
tration sh w ready to be **mounted** on the sub frame. First
The **differen** **gine** in place and bolt it down. We then attach
gear case. T (46), **exhaust pipe** (47), **muffler** (48) and **start-**
used in the diff
The last mention

ing crank (43). (see charts 31 and 32, pages 62 and 64).

The **running boards** (26) are attached to the brackets on the side of the frame—handy for holding tools while working on chassis.

four cylinder T-head engine—it could be a 4, 6, 8, or 12 cylinder, and the cylinders instead of being cast in pairs could be cast singly or in-block.

*Although the above is a **Improvements: most of the** power plants of today are "unit power plants." The clutch and transmission are in one unit with the engine (see principle, page 44).

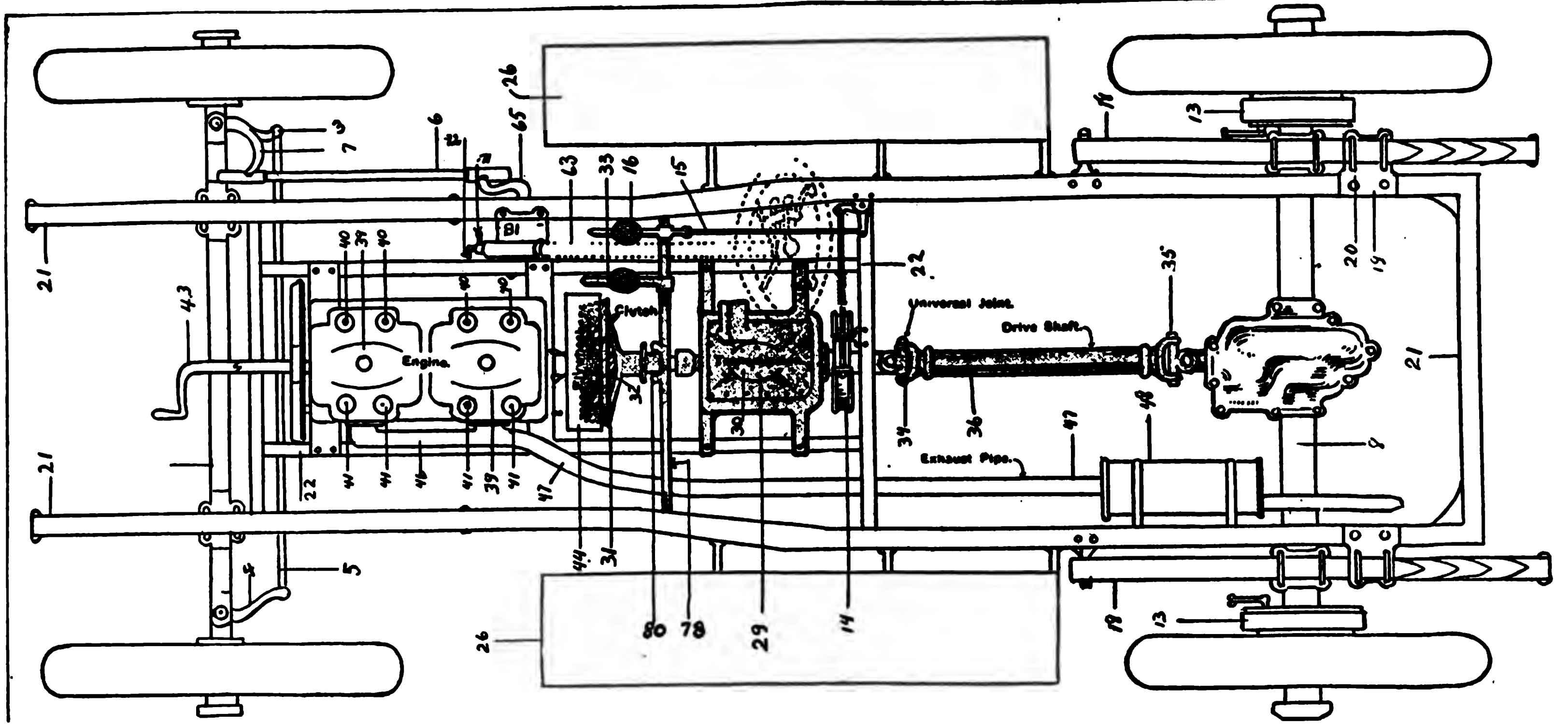


CHART NO. 6—THE PARTS FOR THE TRANSMISSION OF POWER consisting of the Clutch, Transmission and Drive Shaft are now added.

The *clutch (31) which is of the cone type (see chart 19, page 38) is placed in the fly wheel. The **clutch pedal shaft** (78), **clutch pedal** (33), **clutch yoke** (80) and **brake pedal** (16) are next mounted. The pedal (33) is fastened to the shaft (78) permanently. When this pedal is pressed by the foot, the yoke (80) forces the clutch from the fly wheel. When it is released, the spring (32) inside of the clutch forces the clutch back into the fly wheel. See Dyke's working model of transmission and clutch.

A **clutch shaft** extends from the clutch to the main drive gear shaft in the transmission (see pages 19 and 38).

The **transmission is bolted to the sub frame. The shaft from the transmission extends to a **universal joint** (34) then the **drive shaft** (36) extends to the rear universal joint (35) which connects with the **axle drive pinion shaft** (12), Illustration No. 3. The teeth on the **axle drive bevel pinion** (11), mesh with the teeth of **axle drive bevel gear** (10) on the **differential** (9).

---

*The clutch on this car is a cone type. A multiple disc type could be applied with same principle, see page 50 for the drive system showing the modern single plate clutch.

**The transmission on this car is the selective type—three speeds. The planetary or the progressive type could be used, but the progressive type is seldom used, being more or less obsolete. The planetary is used only on light cars, such as the Ford. It has but two speeds.

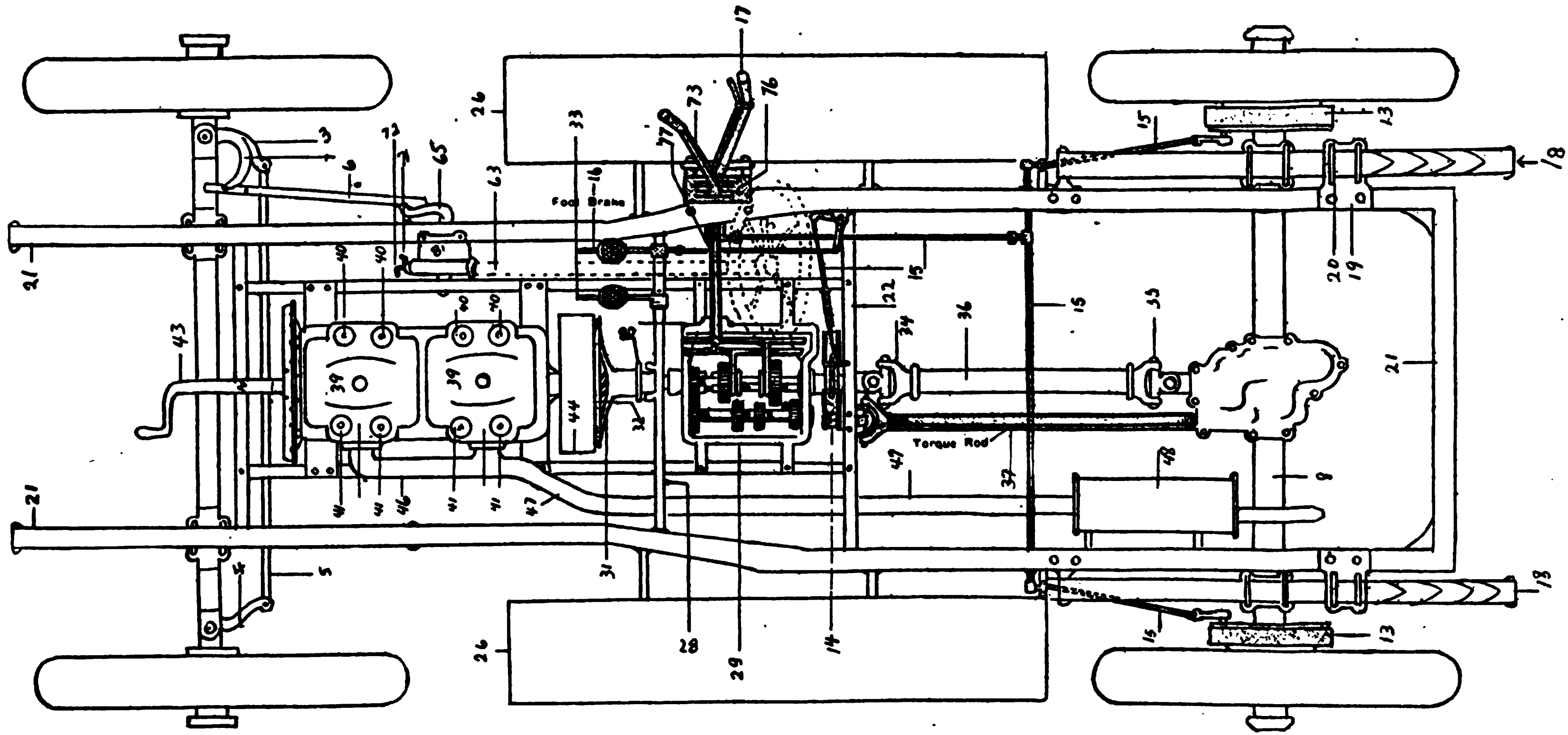


CHART NO. 7—THE CONTROL SYSTEM consisting of **Gear Shifting Lever, Brake Lever, Brake Rod and the Steering Gear Assembly are now added.**

The **gear shift lever** (73) and ****emergency brake lever** (17) are attached to the side of the frame in this illustration, but the modern method is to place them in the center per page 486. The full description of this gear shifting arrangement is shown on pages 48 and 49.

The **hand brake lever** (17) is seldom used for braking purposes only in case of emergency and when the car is standing on an incline. The lever can be locked in its ratchet. This brake control, on some cars, also connects with the clutch, so that when the brake is applied the clutch is thrown out simultaneously—this principle used on the Ford and Chevrolet.

The **brake pedal** (16) is not fastened to the shaft (78) but works free over it. This pedal connects through a system of rods and a bell crank to the Band Brake (14) which is mounted over the pulley on the transmission drive shaft (see chart 16). This brake is called the **foot brake,** as it is the brake used principally when running.

The **torque rod** (37) (sometimes called torsion rod) is now attached. There are several types of torque rods, see page 22.

The next step will be the installation of the ignition and carburetion systems and smaller parts of the power plant.

**When on transmission shaft, known as Transmission Brake.

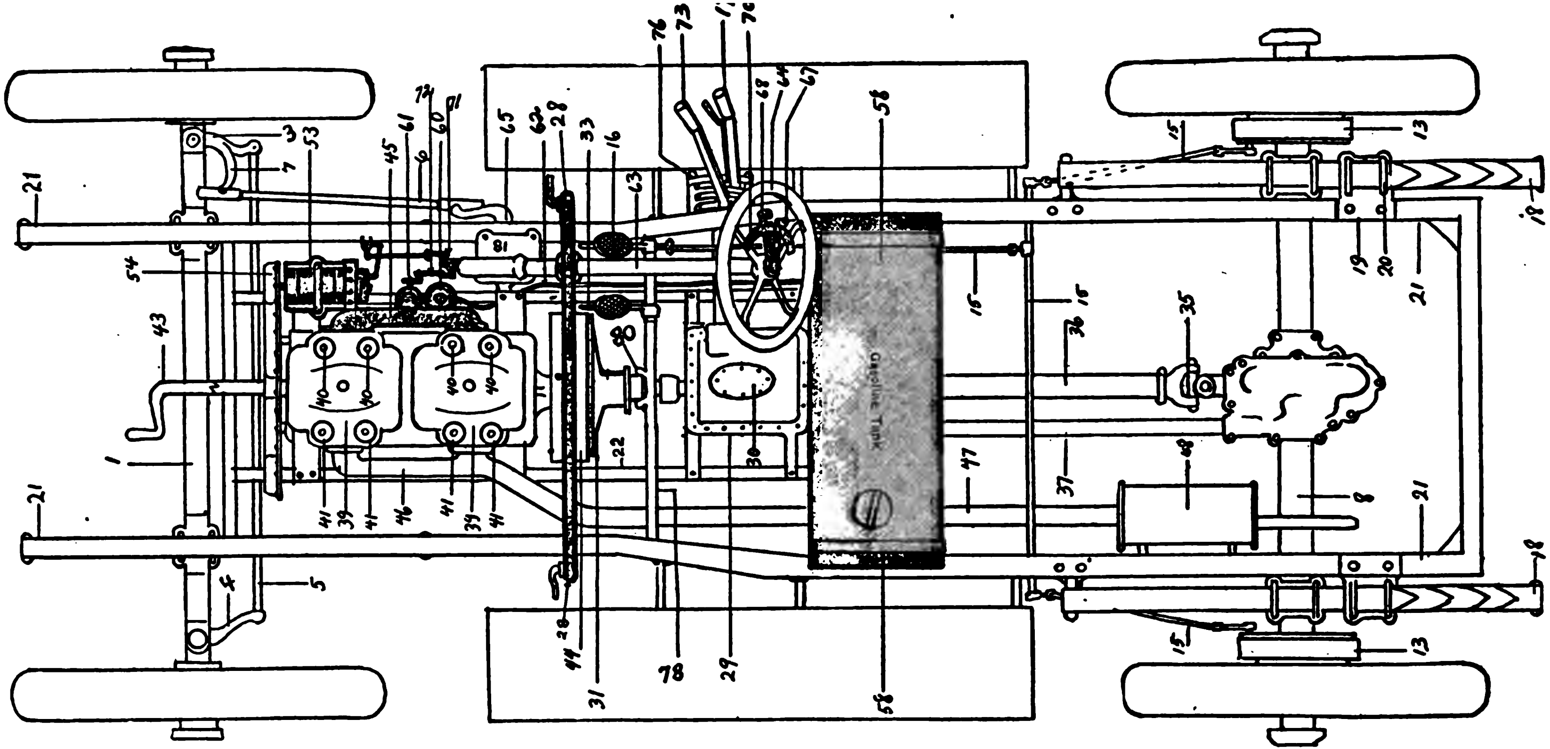


CHART NO. 8—A COMPLETE CHASSIS is now shown with the Control System, *Fuel System, Carburetion and Ignition System added.

First we will connect the inlet manifold (45). The **carburetor** (60) is then connected to the manifold. The **gasoline pipe** (62) is connected to the **carburetor,** thence to the **gasoline tank** (58) (see Instruction 12). The **throttle lever** (68) on steering wheel connects with throttle (61) on the carburetor by means of rod (72) which passes through the steering column tube (63) and connects by means of bell cranks, etc., (see chart 33, page 66).

†The **magneto** (53) is mounted to the side of the engine on a special bracket provided for same and geared to the cam shaft gear (see pages 294 and 302).

The **spark lever** (67) connects with the interrupter or "breaker box" (see page 66) on the magneto (or timer if a timer and coil is used) by means of a shaft passing through the steering column and by means of bell cranks. If a jump spark coil and timer is used, see chart 106, page 222.

The **dash board** (28) should now be added. This board supports the ignition and lighting switches and various instruments, as ammeter, oil pressure gauge, and the bracket to brace the steering column. The dash is attached by bolting to the frame.

***For different methods of gasoline feed; gravity and pressure, see pages 163 and 165. The modern method is the Vacuum system.**

†Other types of ignition (such as the coil and battery system with the distributor and timer) are now more universally used than the magneto. See page 245. Also see page 342 for the Electric Starting Motor and Generator.

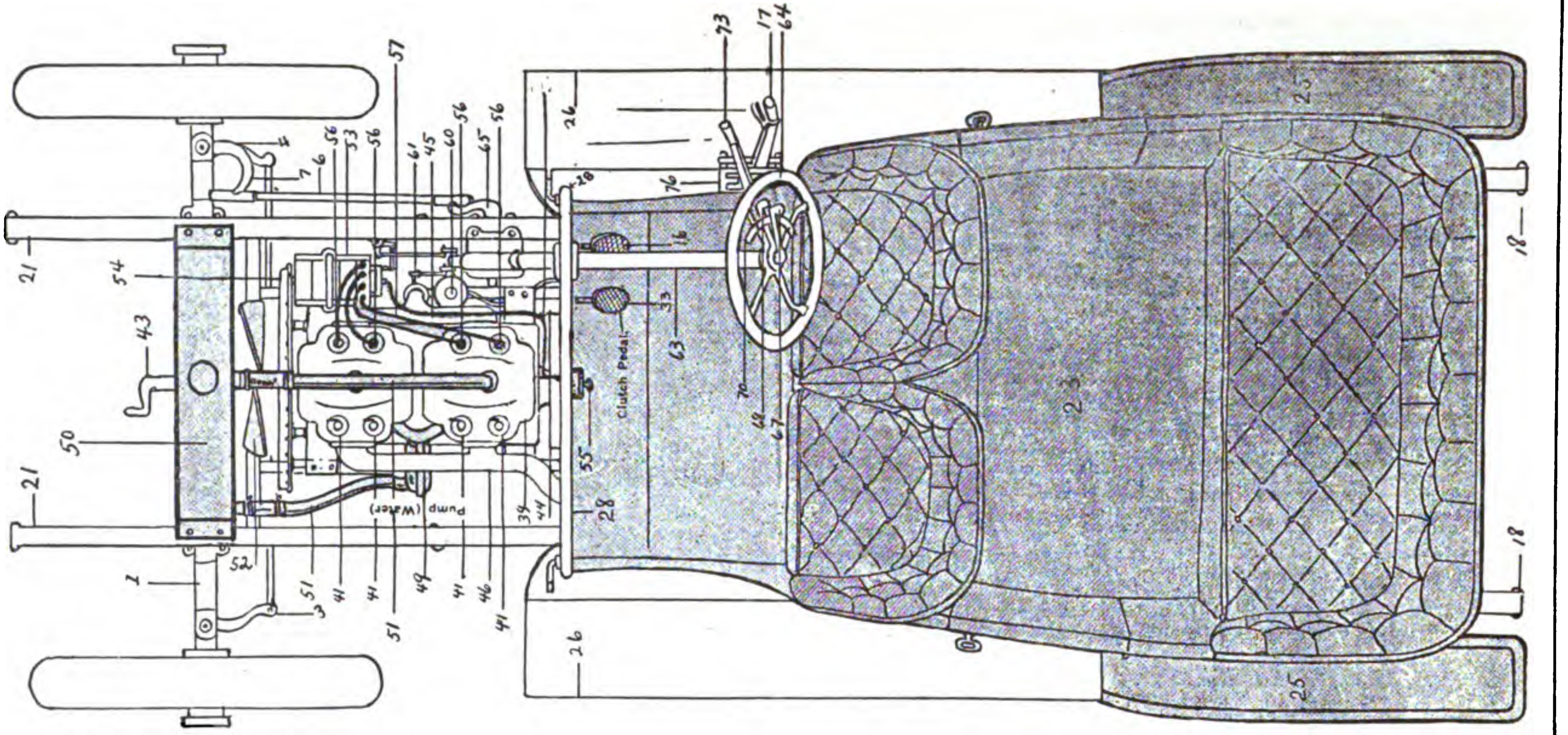


CHART NO. 9—WIRING: **The *Ignition System and the †Electric Starting, Generating and Lighting System are now connected up. Cooling System, Body and Fenders are also added.**

The **high tension cables or wires** (57) are run from the high tension magneto (53) to **spark plugs** (56) (see pages 294 and 296).

The **switch** (55) is placed on the dash and connects with magneto (page 268).

The **radiator** (50) is mounted on the front end of the frame. Water pipes (51) are connected from bottom of radiator to the water **circulating pump** (49) by pipes, thence around the cylinder to outlet pipe (51) to top of radiator—see chart No. 1.

Some cars do not have a **water circulating pump** but use what is called a thermo-syphon system of circulation—see page 185. The **fan** (52) is now connected (see page 187).

The lubrication system for engine is not shown on this illustration—see page 196.

***Some times two systems of ignition are used;** a coil and battery and magneto, called a "Dual" system (see page 286).

†The electric starting, lighting and generating systems are not shown, see foot note bottom page 9.

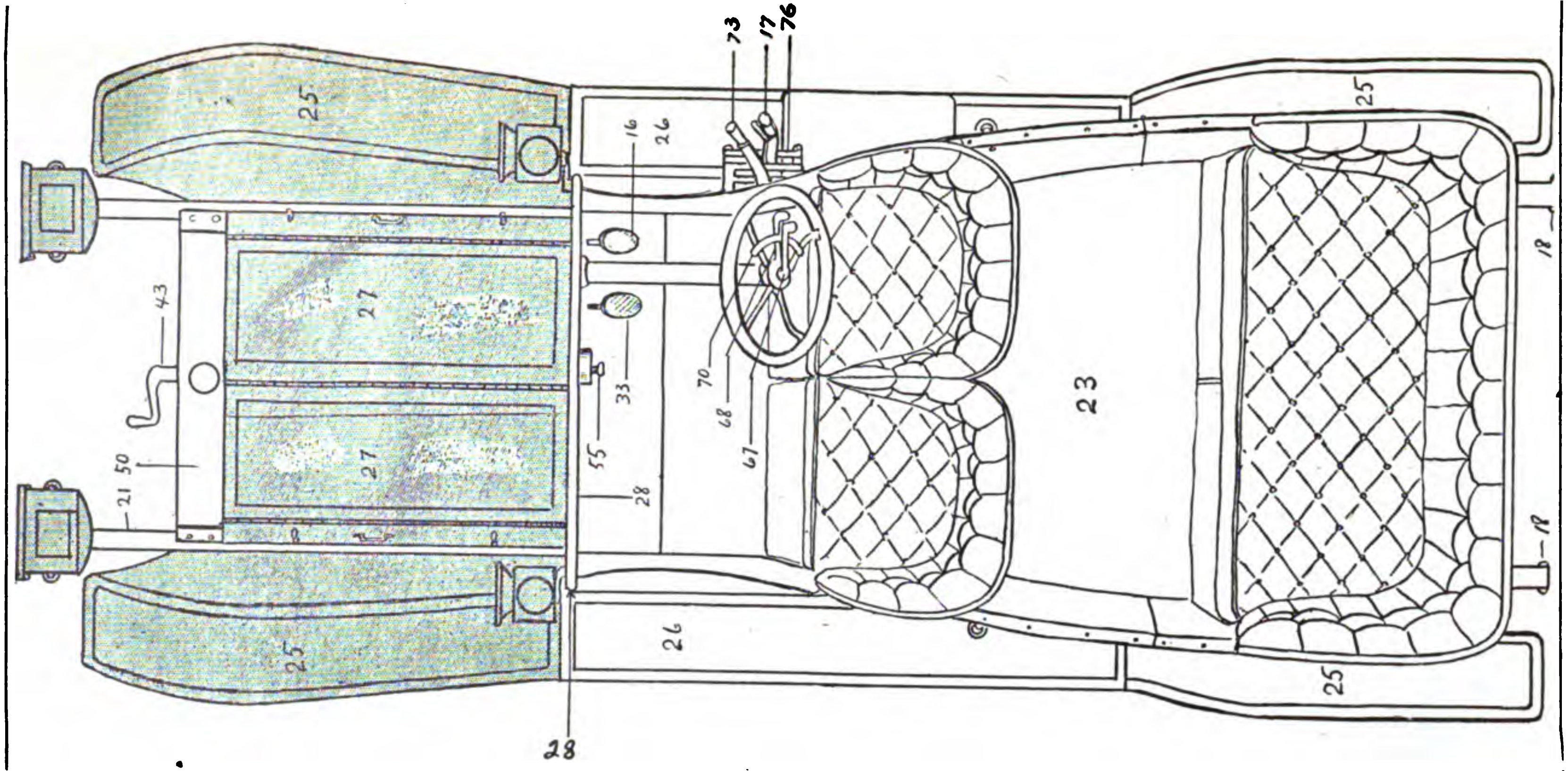


CHART NO. 10—The Completed Car.

†The **body, fenders** and the **hood are now added.**

Painting: the body is usually upholstered and painted separate from the mechanical part of car. The fenders and hood are usually enameled, which requires a heat treatment.

***The electric system on this car is a high tension magneto.** The electric system on a modern car, consisting of **ignition, storage battery, electric generator and starter** is not shown in this illustration, but is fully treated further on. See pages 204 and 357 for **location of battery,** starting motor, generator and ignition system of a modern car and pages 369 and 342 for plan of connections of these parts.

A lighting system, which is usually electric, is not shown in this illustration, see pages 342 and 426 for wiring principle.

To prepare car for service—see page 487. To start engine, start car and operate car, see pages 486 to 493.

---

†We have now illustrated a car built of standard parts. **While the construction may** vary in form of the number of cylinders to engine, a disk clutch instead of the cone and other forms of construction—the principle remains the same.

*The only electric system on this car is the high tension magneto which supplies current for ignition only (see fig. 1, page 276). A majority of modern cars do not use the magneto but use the battery and coil system of ignition in connection with a mechanical generator or dynamo which charges the battery. **See bottom of page 287 and page 342.**

INSTRUCTION No 1.

THE AUTOMOBILE: Assembly of the Automobile. Functions of the Principal Parts.

The Kinds of Motor Cars.

There are three different kinds of motor cars; first, the gasoline motor car; secondly, the steam car; thirdly, the electric car.

The gasoline motor car is by far the most popular, and it is with this that we are mainly going to deal.

The steam car, silent, smooth and easy on tires, is comparatively seldom seen.

The electric car, almost invariably in the form of a brougham or coupe, is heavily handicapped by being unable to run for more than a few hours without a fresh charge of electricity from its headquarters, and is quite in the minority. Our attention will be devoted to the car with the gasoline engine for the motive power.

The Component Parts of a Motor Car.

A car may be made up as a whole of two distinct parts, the body and chassis.

The body, which is the work of the body builder, which has been brought by him to a wonderful pitch of perfection, hardly concerns us so we will unscrew the half dozen or so bolts that secure it to the frame of the chassis and stand it to one side, for the present at least—so that we can examine the chassis underneath.

The chassis is the entire car with the exception of the body (see chart 8). The chassis, for our purpose, must also be divided into its main parts as follows: the running gear, power plant, transmission system, control system, equipment and accessories.

The running gear consists of parts as follows: front and rear axles, wheels, springs, frame.

The power plant consists of parts as follows: motor with its fuel system, carburetion system, ignition system, cooling system and lubrication system.

The transmission system consists of parts as follows: clutch, change speed gears, drive shaft with its universal joints and differential.

The control system consists of parts as follows: steering device, throttle and spark control, hand levers, foot pedals and brake system.

The necessary equipment consists of such parts as fenders, running boards, hood, dash, tires, lighting system, self starter, horn, etc.

The desirable equipment or accessories are such parts as speedometer, windshield, warning signal, shock absorbers, etc.

The construction of the parts of a motor car may vary, but their purpose is the same. While it is true there are hundreds of different firms making automobiles, they all employ in the construction of their cars the parts enumerated under the various headings. For instance, one manufacturer may suspend the power plant on the main frame, others use a sub-frame. Some use a clutch of the cone type, others use a clutch of the multiple disc type—but they all use frames and they all use clutches. Further on we will explain the different constructions involved in these parts, but bear in mind the principle or purpose of each part does not change.

As we progress the reader will gain an idea of the different constructions of the component parts now in general use—for instance, there are two kinds of front axles in general use; the tubular type and the solid type. There are two types of construction of rear axles in general use; the live axle which revolves and is driven by a bevel gear and pinion, and the dead axle which does not revolve, but the wheels are driven by chain and sprocket, and so on, throughout the whole construction of a car.

*It is now clear that if the reader masters the **principle and purpose of these parts** then it will be no difficult matter to understand the variation in construction, and when he will have completed the study of this construction he will have gained sufficient knowledge to enable him to understand the construction of **all cars.**

Purpose of the Parts of the Running Gear—see chart 4.

The front wheels run free on the axle, and guide the car. They are called the guiding wheels and are moved from side to side by means of a steering device (63-64-65) and the direction of the car is controlled in this manner. The rear wheels are revolved by the engine and drive the car.

The front axle is fitted with **steering knuckles** (3 and 4) on which the guiding wheels run. These steering knuckles are moved by means of the rod (6), which connects to the steering device (65). The front axle is fitted with **spring blocks** (19) and spring clips (20) which hold the springs in place.

The rear axle revolves. The housing over axle is fitted with spring blocks and clips similar to the front axle.

The springs act as a cushion and protect the machinery and the occupants of the car from undue vibration and shock. They also hold the frame.

The frame of an automobile is made of pressed steel and is the foundation which supports the power plant, change gears, levers, steering device, fuel tank, body, etc. Each part is bolted to frame and is kept in proper relation to each other. The frame is usually hung, with the springs resting on the axles as shown in upper illustration, fig. 1, to the left, called **overslung**. Sometimes the springs are fastened below the axles, called the **underslung** construction.

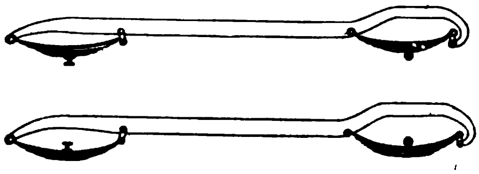


Fig. 1. In the upper illustration is shown the **overslung** spring suspension which is used on the majority of the cars today. Note that here both front and rear springs and also the frame are above the axles. In the lower illustration is shown the **underslung**, a form of spring suspension in which the frame is above the axles, but the springs below —seldom used.

A popular spring system is the cantilever, see page 27.

A sub-frame is sometimes placed inside of the main frame to support the power and drive plant.

The steering device (63-64-65) is usually attached to the frame. By turning, the wheel (64) the car is guided through the control of the direction of the front wheels.

Brakes (13) are fitted to motor cars for stopping or slowing down and are usually fitted to a drum on the hubs of the rear wheels.

Purpose of the Parts of the Power Plant—see chart 5.

The engine furnishes the power that drives the car. It is usually located in the front part of the frame, if it is a multiple cylinder vertical type of engine.

***Suspension:** multiple cylinder engines usually have four, six, eight or twelve cylinders. If it is a single cylinder engine, it is usually hung as shown in chart 11, fig. 1; if double cylinder opposed type, it is usually placed across the frame. If a multiple cylinder, "**single unit power plant**" (see page 85), it is usually suspended at three points as per page 786, fig. 49. This is called "**three** point suspension."

---

*See index for advantages of "three point suspension."

*The type of clutch, axle, engine, etc. which are used on leading cars given under "Specifications of Leading Cars"—page 542.

The carburetor mixes air with gasoline, and is connected direct to intake pipe on engine. The carburetor is connected to the feed pipe (62) from the gasoline tank.

The gasoline tank is usually placed under the seat or at the rear of the car and gasoline is fed to the carburetor through a small pipe (62) (chart 8) or by the vacuum system (see carburetion instruction).

The exhaust pipe (47) connects to the exhaust manifold and runs to muffler (48), which is usually placed at rear of car. The exhaust pipe permits the burnt gases to escape. **The muffler** placed at the extreme end of the exhaust pipe, silences or muffles the noises from the explosions in engine cylinders.

The ignition system is a part of the electric plant; either a storage battery and coil, dry cells and coil, generator, or a magneto. The coil and battery electric system was formerly placed on the dash, while the magneto or generator is placed on the engine and is run by the cam shaft or crank shaft, through the medium of silent chains. The modern coil and battery system with a timer and distributor is now placed on the engine, see Delco and Atwater-Kent systems.

The cooling system consists of the radiator (50), water pipes (51) and circulating pump. The object of the cooling system is to keep the engine from getting too hot when the explosions take place inside of the cylinders.

The lubrication system of the engine is for the purpose of keeping the bearings and rings and other moving parts from wearing. This subject as well as all other subjects will be treated separately further on.

Transmission of Power—see charts 6, 7.

The transmission or the speed change gears is that part which transmits the power from the engine to the driving wheels through a system of speed change gears (29).

A clutch (31) is placed between the engine and transmission; this permits the engine to run free, or when "thrown in" connects the engine to the change speed gears and drive the car. The clutch is operated by a foot pedal (33) and is thrown in or out by the driver.

In a locomotive, the piston rods are connected direct with the wheels, through the medium of the cross head, and connecting rods so that when steam is applied the locomotive moves. In an automobile, the engine may be disconnected from the transmission by means of the clutch, so that the motion of the transmission or of the entire car may be stopped without stopping the engine.

Change gear principle: When a bicyclist wants to race on a level track he gears his wheel up high, so that one revolution of the crank takes him the greatest possible distance. Yet if he takes this wheel on the road and encounters a hill, he must get off and walk or exert an extra lot of power—he needs a wheel geared lower.

In the same way, when an engine is required to do more than ordinary work, as climbing a hill, the transmission or change speed gear contains from two to four changes of gears and helps out the engine by changing to the gear ratio required for less motive power. It allows the car to move at various speeds while the speed of the engine is unchanged.

When in low gear, the engine makes quite a number of revolutions (15 or 20), while the wheels revolve once which makes the auto move forward slowly, but with considerable force, so that it can go up a steep hill or through sand or mud.

When in second or intermediate gear, the engine makes from (8 to 12) revolutions to one revolution of the wheels, which moves the car faster than the low or first change of gears but with less force.

When in third or high gear the engine makes from (2 to 4) revolutions to one revolution of the wheels, which gives the car high speed over good roads.

If the car was going up a steep grade while on high gear, the work would be more than the engine could do, and it would stop unless one of the lower speeds were shifted in. There would be considerably more pull on the wheels.

The operation of the change of gears is by means of a **side or center lever** (73, chart 1, also see chart 23); change of gears can be made instantly. The **transmission** also contains a set of **reverse gears**, which when thrown in, will **reverse** the motion of the car without reversing the motion of the engine.

The transmission may be connected so that it **drives the wheels by the following methods.**

First—by a **driving shaft** (see chart 11, fig. 1, c and e, also (36) chart 6), connected to the rear axle, which it revolves by means of bevel gears, the wheels and axle turning together. This axle revolves and is called a "**live**" axle.

Second—by a **single chain** (see h, chart 11) connected to the rear axle, wheels and axle turning together.

Third—by **two chains** (see b, chart 11), one connected to each rear wheel, which run free on the axle, like a buggy and is called a "**dead**" axle because it does not revolve.

The Drive System—see chart 6.

The connection between the engine and the wheels is called the drive system.

The **drive shaft** connects with the end of the transmission shaft by means of a universal joint, it has also a universal joint at rear end connecting with the differential drive pinion shaft.

The **universal joints** (34-35) permit the parts mounted on the rear axle to move up and down, thus preventing the movement of the axle from interfering with the drive of the car.

The torque rod (37) is usually placed between the housing on rear axle and the transmission case. The object of the torque rod (or torque arm as it is now called) is to prevent the axle housing from twisting when the power or brakes are applied (see page 22).

The **drive pinion shaft** (12) connects to the rear universal joint (35) and drives the bevel gear (10), which is connected to the differential (9), (see chart 5).

The front wheels on an automobile run free on the axle. For this reason the outside wheel is able to revolve faster than the inside wheel when the car is turning a corner.

When a vehicle turns a corner, the outside wheels revolve faster than the inside wheels, because they travel a longer distance.

The wheels in rear must do the same thing; if they were forced to revolve at the same speed, one would slide because it could not keep pace with the other.

When they run free on the axle, they would take care of this themselves, but as both are driven by the engine, the transmission or rear axle is fitted with a **differential**, or at times erroneously called a **compensating gear** (see chart 18). This device is automatic, and permits the wheels to revolve at variable speeds, although both are driven by **the engine**.

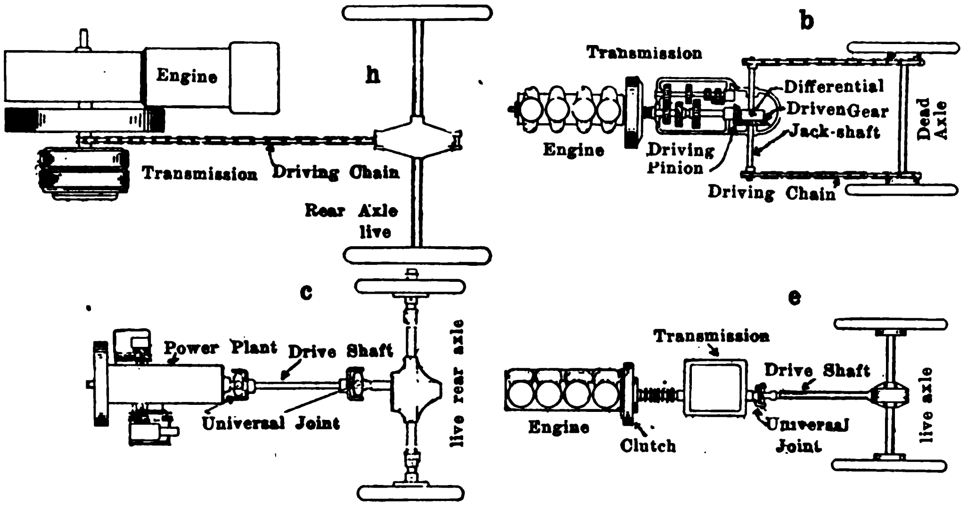


Fig. 1—Methods of Power Transmission to Rear Axle.

h—Single chain drive (obsolete). b—Double chain drive (used principally on trucks). c—Shaft drive with a double opposed type of engine (shaft drive is extensively used, but the opposed type engine is seldom used). e—Shaft drive with a four, six, eight or twelve cylinder engine (extensively used).

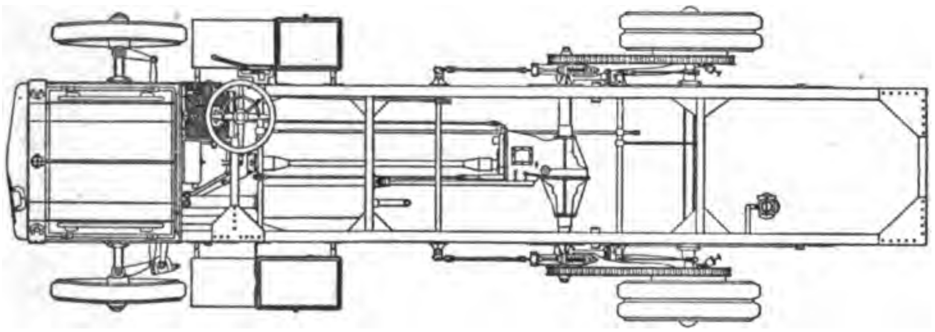


Fig. 2—Top view of a double chain driven truck. Rear axle is called the "dead" type because it does not revolve. Formerly employed by the Packard Motor Car Co.

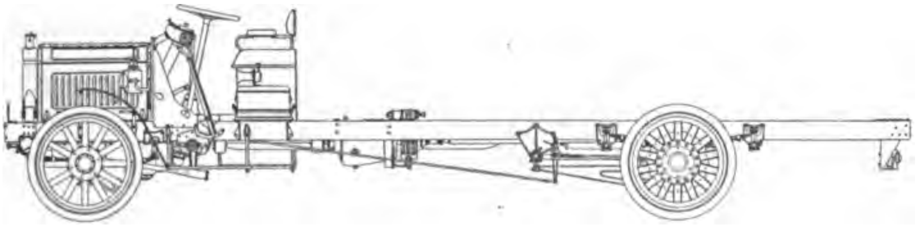


Fig. 3—Side view of a modern Packard chainless truck. Drive; worm: power; four cylinder gasoline engine; clutch; disk: transmission; four speed selective sliding: "live" rear axle; full floating.

Worm gear drive. This system is used on a large number of cars now, especially on trucks, and is coming more into favor every year. There is no difference in the transmission system, except as regards the drive, as compared with the usual bevel-gear system. In principle the worm drive is a simple arrangement; the usual bevel gear and pinion are replaced by a specially-shaped hollow helical toothed gearwheel and worm. A "live" rear axle is used.

HART NO. 11—Methods of Transmission of Power to Rear Axle and Road Wheels.

Body.

The automobile frame, with all parts of the running gear, the **transmission**, engine and other parts of the mechanism, when it is **without the body** is called the **chassis**. Different types of bodies may be attached to a **chassis**, and are generally fastened down with bolts.

The bodies of pleasure automobiles are classed as follows:

Roadster—An open car seating two or three. It may have additional seats on running-boards or in rear deck.

Coupelet—Seats two or three. It has a folding top and full-height doors with disappearing panels of glass.

Coupe—An inside operated, enclosed car seating two or three. A fourth seat facing backward is sometimes added.

Convertible Coupe—A roadster provided with a detachable coupe top.

Clover Leaf—An open car seating three or four. The rear seat is close to the divided front seat and entrance is only through doors in front of the front seat.

Touring Car—An open car seating four or more with direct entrance to tonneau.

Salon Touring Car—A touring car with passage between front seats, with or without separate entrance to front seats.

Convertible Touring Car—A touring car with folding top and disappearing or removable glass sides.

Sedan—A closed car seating four or more all in one compartment.

Convertible Sedan—A salon touring car provided with a detachable sedan top.

Open Sedan—A sedan so constructed that the sides can be removed or stowed so as to leave the space entirely clear from the glass front to the back.

Limousine—A closed car seating three to five inside, with driver's seat outside, covered with a roof.

Open Limousine—A touring car with permanent standing top and disappearing or removable glass sides.

Berline—A limousine having the driver's seat entirely inclosed.

Brougham—A limousine with no roof over the driver's seat.

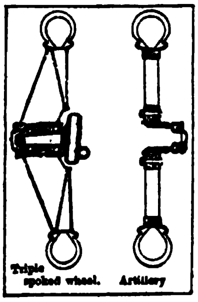
Landaulet—A closed car with folding top, seats for three or more inside, and driver's seat outside.

Body equipment consists of a **hood** or **bonnet** over the engine which connects with the **dash** of the body. Fenders or mud guards are usually attached independent of the body, also the **running board. Wind shields** are placed in front on the dash. **Steel pans**, which extend under the mechanism, protecting it from mud and dust.

Commercial vehicles are those used for business purposes such as taxicabs, delivery and trucks.

Wheels.

Tires made of rubber are fitted to the wheels to take up the vibrations that are too sudden for the springs to absorb.



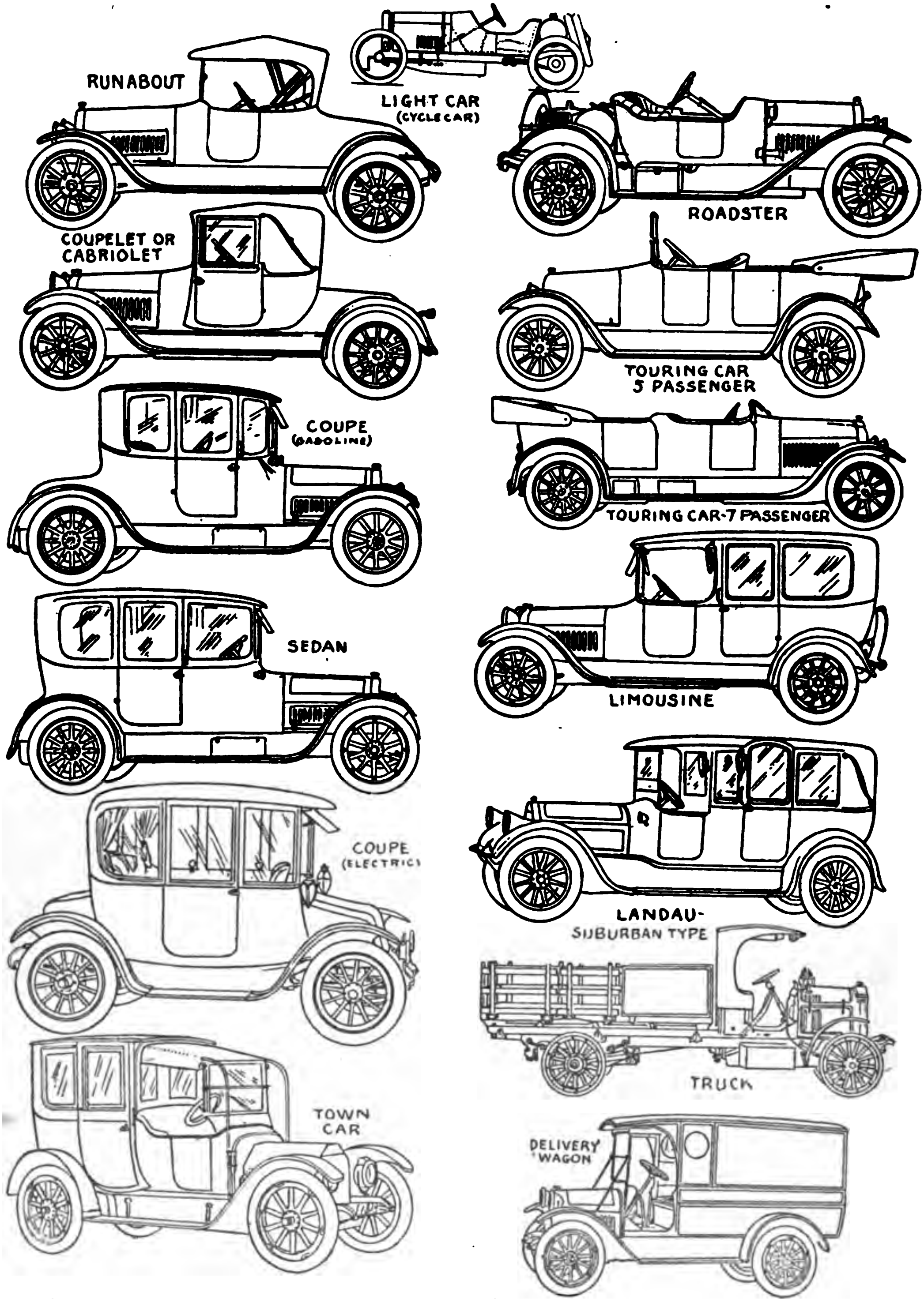
Triple spoked wheel. Artillery

The wheels of an automobile are smaller in diameter than horse drawn vehicles, due principally to the fact that at the high speed the automobile travels, the wheels would have to be built entirely too heavy to sustain the strain. Automobile wheels must be very strong, because of the weight that they must support, and the strain that they are under. They are made of wood or wire (see illustration).

Wooden wheels are made with a wood felloe, over which fits a steel rim that holds the tire. It is called an artillery type wheel.

Wire wheels are light, easily repaired and are becoming very popular.

Mud guards or fenders are always fitted over the wheels, to protect the car and occupants from the mud thrown by the wheels.



Although there are many special makes of bodies which are given special names, the above illustrations will give the reader the names of the standard type of bodies.

Note the Cycle Car is now called a Light Car.

The Sedan differs from the Limousine in that the driver's seat in the Sedan is placed inside with other seats and would be termed a family car. The owner quite often drives this type of car.

The Limousine front seat is partitioned off from seats in the rear and is usually operated by a chauffeur.

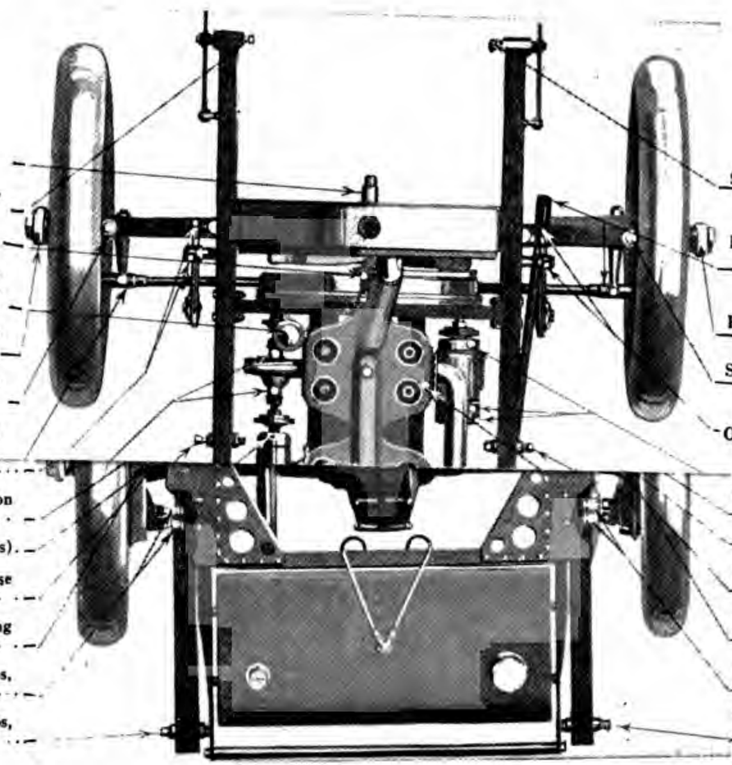
The Town Car is a light, low, short wheel base, with chauffeur's seat in front. This type of car also used for Taxicab service.

The Landau is a type of car similar to the Limousine, but the rear part of top can be folded back.

The distinction between the Delivery wagon and Truck is in size and weight. The delivery wagon is usually a shaft driven pneumatic tired car, whereas the truck is a double chain or shaft driven solid tired heavy machine.

ART NO. 12—Types of Bodies.

Daily	300 Miles	475 Miles	500 Miles	1000 Miles	5000 Miles	
				E		Oil Starting Handle
A						Spring Eye Bolt Grease Cups, (12)
				E		Oil Radiator Fan.
		C				Crank Case—38 H.P., 11 pints; 48 H.P., 13 pints; 66 H.P., 14 pints of cylinder oil.
					F	Front Hub Caps, (fill with grease).
A						Steering Knuckle Pivot Grease Cups, (2).
					F	Leather Boot over Steering Rod End, (fill with Kasson Com- Cup, (2).
			D			Oil Brake Levers and Joints on Hub Brakes, (4 places).
			D			Oil Shock Absorbers, (8 places).
	B					Rear Axle Spring Seat Grease Cups, (2).
				E		Driving Axle Outer Bearing Grease Cups, (2).
A						Brake Shoe Pin Grease Cups, (4).
A						Spring Eye Bolt Grease Cups, (12).

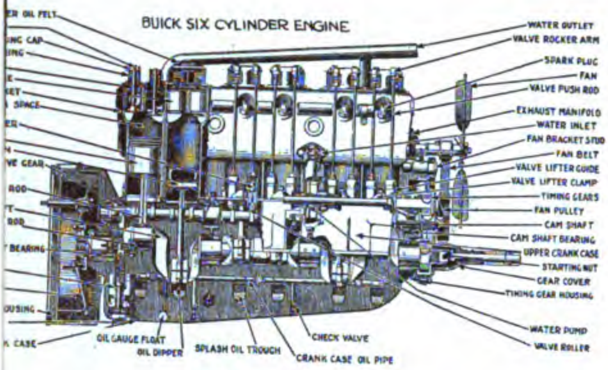


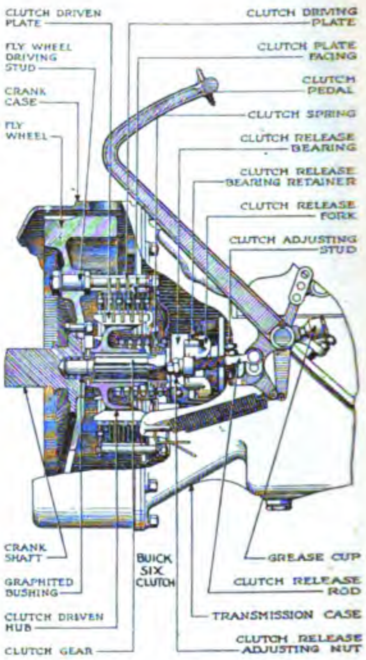
	Daily	300 Miles	475 Miles	500 Miles	1000 Miles	5000 Miles
Spring Eye Bolt Grease Cups (12).	A					
Leather Boots over Steering Rod Ends, (fill with Kasson Compound).						F
Front Hub Cap, (fill with grease).						F
Steering Knuckle Pivot Grease Cups, (2).	A					
Oil Shock Absorbers, (8 places).				D		
Oil Brake Levers and Joints on Hub Brakes, (4 places).						
Oil Shock Absorbers, (8 places)				D		
Rear Axle Spring Seat Grease Cups, (2).		B				
Driving Axle Outer Bearing Grease Cups, (2).					E	
Brake Shoe Pin Grease Cup, (4).	A					
Spring Eye Bolt Grease Cup, (12).	A					

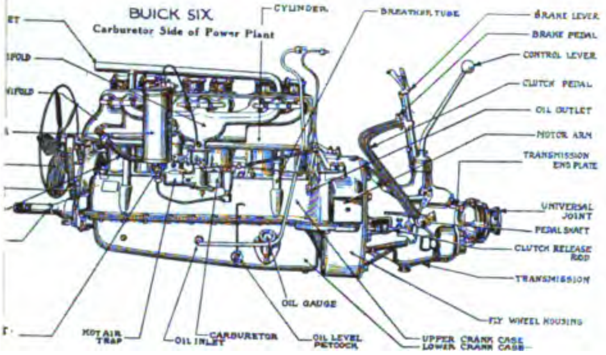
The Pierce-Arrow: engine,
site side, operated from two
inder dimensions of the three
bore 4", stroke 5½", speed
6 cyl., bore 4½", stroke 5½"
engine, 6 cyl., bore 5", strol

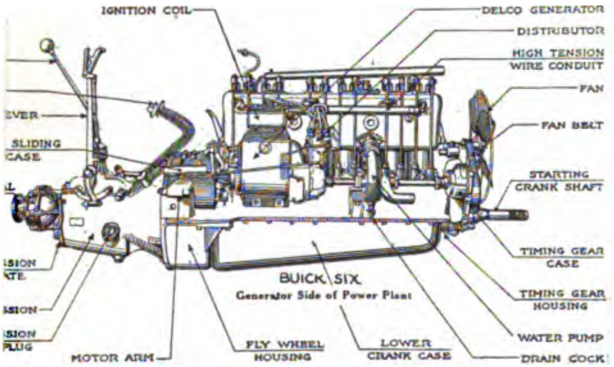
soline feed is by air pressure similar to the
on page 854. One pipe from fuel tank in rear
wer and hand air pump and is the air pressure
the fuel feed pipe to carburetor. **Gear shift**
board is shown on page 500, and spark and
page 496.

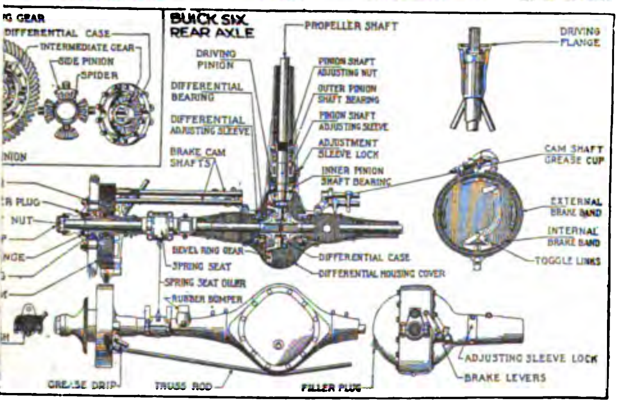
NOTE—The latest model Pierce-











Buick Six.

The Buick 1918 line is composed of three models. Two are sixes and the only material difference is in the wheel base, which is 118" and 124"—the engines being the same.

Specifications: wheel base 124"; engine, 6 cylinder, four cycle valve-in-head type; unit power plant (see also pages 109 and 157); bore 3⅜"x4½" stroke, 60 h. p.; cooling, centrifugal pump and cellular type radiator; lubrication, circulating splash operated by gear pump driven by spiral gears from cam shaft; carburetor is the Marvel shown on page 179, with vacuum fuel feed system explained on page 165; ignition, high tension jump spark system—Delco—see page 378; electric system, Delco single wire, see page 388. Clutch, multiple disc, dry plate; transmission, 3 speed and reverse, 3.36, 1.76 and 1 to 1 on first, second and third gears, and 4.32 to 1 on reverse, selective type—see page 497 for gear shift; rear axle, full floating type with 4 to 1 ratio on 118" wheel base and 4.615 to 1 on the 124" wheel base car—see page 557 for type of rim used.

Buick Four.

On the four cylinder car the engine is also valve-in-head type with bore of 3⅜x4¾" stroke—pump cooled, splash lubrication—Delco electric system—cone clutch—¾ floating axle.

Lights.

Automobiles are required to carry **two lights in front**, and another, called the tail light, in the rear. The rear light is required for the benefit of the Fire Department—to avoid accidents of rear end collision. To make driving at night safe, there are usually head lights which burn acetylene gas or electricity.

Electric lights are the most popular; a storage battery supplies the electric current; when the battery runs down it is recharged from an outside source, but if car is equipped with an electric generator, run from engine, the battery is kept charged by the generator. (This subject treated further on).

Accessories.

Speedometers show the speed in miles per hour, and are operated by flexible shaft driven from the front wheel or transmission shaft.

Odometers show the number of miles traveled, either on one trip or during the entire season. Speedometers and odometers are often built in one case, for the sake of compactness, one cable driving both.

Grademeters show the per cent of grade the car is climbing.

The horn for automobiles is sounded by pressing a rubber bulb, and the tube from the bulb to the horn is long enough to have the former at the driver's seat, and the latter well forward. Another form of alarm is blown by the pressure of the exhaust from the engine, and it is sounded by pressing on a foot pedal. Exhaust whistles are the name of these horns, and the sound is very much like a locomotive whistle.

The electric horn is the most popular. It will be explained farther on.

Bumpers are placed in front of the car and sometimes in the rear. They protect the radiator and lamps and are well worth the investment (see fig. 10 page 26).

Wheel Base, Tread.

The wheel base of an automobile is the distance (in inches) between the rear axles and the front axles. The long wheel base rides easier than a short wheel base. The frame must be sufficiently stiff, however, to prevent sagging from the weight on same. The wheel bases vary from 80 inches on runabouts, to 144 inches on larger cars.

The tread (also called track) is the distance the two wheels are apart measured parallel with the axle. The standard tread is 56 inches, measured from center to center.

The treads of wagons and carriages vary in different parts of the country. In the Southern states it is 60 inches, in the West 48, and most of the other parts of the country 56 inches. Small, light cars are sometimes made with a smaller tread than 56 inches, but it is exceptional.

The clearance is the distance from the lowest point of the car to the road. For rough roads, a greater clearance is required than for smooth roads, as a high place in the road would strike parts of the machinery that hung too low. The front axle, which is solid and heavy, is usually curved down in the center, so that it will be the first part of the car to strike a high place, thereby protecting the delicate parts behind it.

INSTRUCTION No. 2.

DRIVES: Chain. Propeller or Shaft Drive. Worm Gear Drive. Radius Rods. Torsion Rods. Drive Reduction.

The power from the engine is transmitted through the transmission; and is applied to the propelling of the car by those parts called the drive.

There are three types of drive; one the **double chain** drive, requiring a dead rear axle, and the other the **single chain drive** (seldom used), and the **shaft or propeller shaft** drive, which requires a live rear axle. (see chart 13.)

*Double Chain Drive—see chart 11.

The double chain drive is seldom used on pleasure cars, but is used quite extensively on trucks. †Trucks use chains, because trucks carry heavy loads and usually have solid dead axles.

When, as is usual in cars of this type of drive, the engine is in front, the **crank shaft** is parallel to the sides of the car, and therefore at right angles to the rear axle. The power developed at the crank shaft must therefore be turned at right angles in order to apply it to the wheels. (See fig. 1, chart 13.) This is done by means of bevel gears, which are in the transmission case.

The power is transmitted from the crank shaft of the engine to the square shaft of the change speed gear by gears, as explained farther on. The square shaft carries a bevel gear that meshes with another bevel gear carried on the jack shaft (see fig. 1).

The jack shaft passes across the car, running in bearings in the gear case and on the frame. It is held so rigidly that while it is free to revolve, its bevel gear is always in correct relation to the bevel gear on the square shaft of the transmission.

The jack shaft is in two sections, between the inner ends of which the differential is placed, the differential, of course, being in a housing to side of the bevel gear that drives the jack shaft.

At each end of the jack shaft, outside of the frame, is a sprocket which is in line with a corresponding sprocket on the rear wheel of that side (see fig. 2, chart 13). Over each pair of sprockets passes a chain that transmits the revolutions of the jack shaft to the wheels which run loose on the ends of the dead axle.

The chain most commonly used for automobiles is called a roller chain. It consists of side pieces in pairs, each pair being secured to the adjoining pairs by rivets passing from side to side. On these rivets are steel rollers which revolve as they touch the sprockets. These rollers fit the space between the teeth of the sprockets, and as the chain bends around the sprockets the rollers are stationary, while the rivets turn inside of them.

To give the best service, chain must run true; that is, the sprockets over which they run must be in line, the links of the chain must fit the teeth, and the sprockets must be exactly circular. If the sprockets are out of line, the chain will be forced to bend sideways. If the links do not fit the teeth, there will be a grinding that will cause rapid wear, and there will be danger of the chain jumping off. If the sprockets are not exactly circular, during one part of the revolution the chain will be slack, and during the other part will be drawn tight, stretching it.

---

*For care and adjusting of chains, see instruction on trucks; also refer to this subject on double chain drive.

†The modern type of truck uses the worm gear drive.

The **double chain drive** has **advantages** on heavy cars. By its use the weight of the car is carried by a **solid** or "dead" axle, which is lighter than a divided "live" axle of the same strength can be. If a solid axle is bent, it can be straightened easily, while it requires an expert mechanic to straighten a bent live axle.

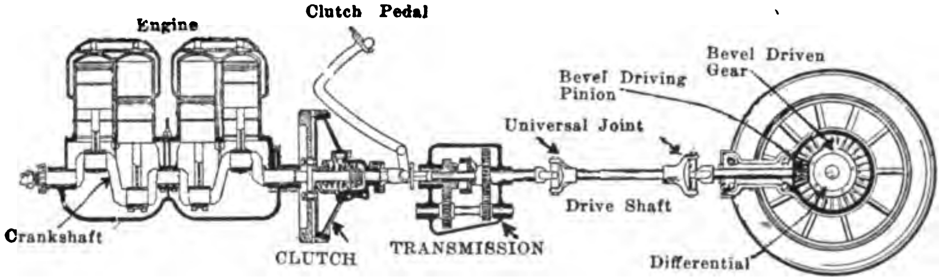
The **disadvantages** of a double chain drive are the difficulty of properly lubricating the chains, their rapid wear in consequence, and the liability of chains to stretch and jump off the sprockets.

The worm gear drive for trucks with substantial axles of the "live" type are now considered superior to the double chain drive.

Single Chain Drive—see chart 11.

This type of drive is now **seldom used,** and was formerly used only for cars with engines of small power, in which the engine is usually horizontal, with the crank shaft lying across the car and parallel to the rear axle.

A planetary change speed gear or transmission is usually used in a car of this type, and its sprocket is in line with the sprocket mounted on the differential on the "live" rear axle (see chart 11—also fig. 5, page 47).



The modern method for driving the rear axle is by means of a propeller type of drive shaft with a bevel driving pinion and bevel driven gear on differential on rear axle.
Commercial cars with shaft drive instead of double chain drive often use the worm drive, see page 21.

***Propeller or Shaft Drive**—see chart 11.

In this type, a shaft connects with the square main shaft of the differential and is extended to the rear axle, where it ends with a small bevel gear called **the axle drive bevel pinion.**

This driving pinion meshes with a bevel gear on the differential **that** is mounted between the inner ends of the two parts of the live rear axle, called the **axle drive bevel gear.**

The propeller or driving shaft, always has one, and often two, universal joints in between the gear box and drive pinion on rear end, so that the moving of the rear end as the axle receives the jolts of a rough road does not affect its driving.

The bevel gears are contained within a casing or housing that supports the bearings for the parts of the axle, and also the end of the driving shaft, so that the bevels are held in the same relation to each other, regardless of the moving of the axle.

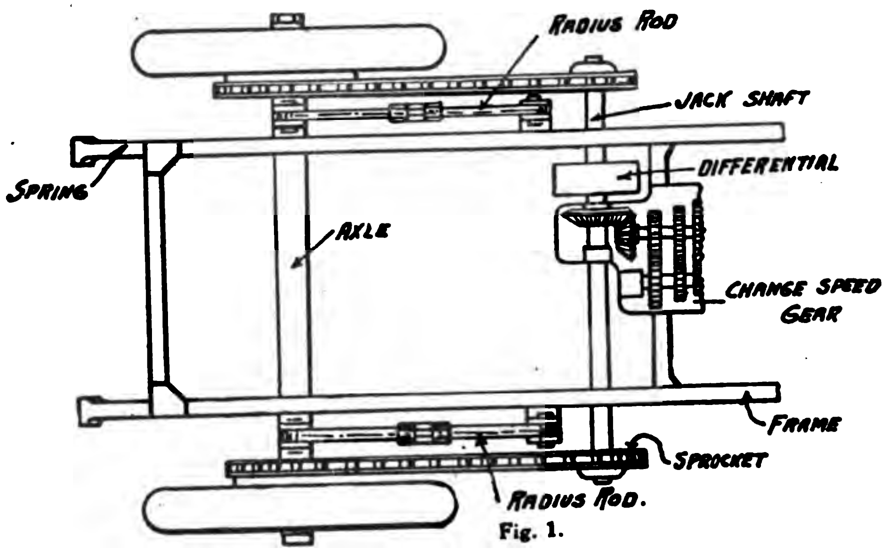


Fig. 1.

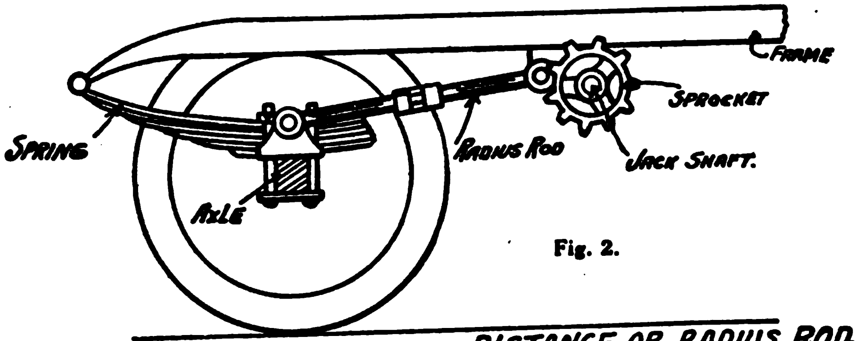


Fig. 2.

DISTANCE OR RADIUS RODS

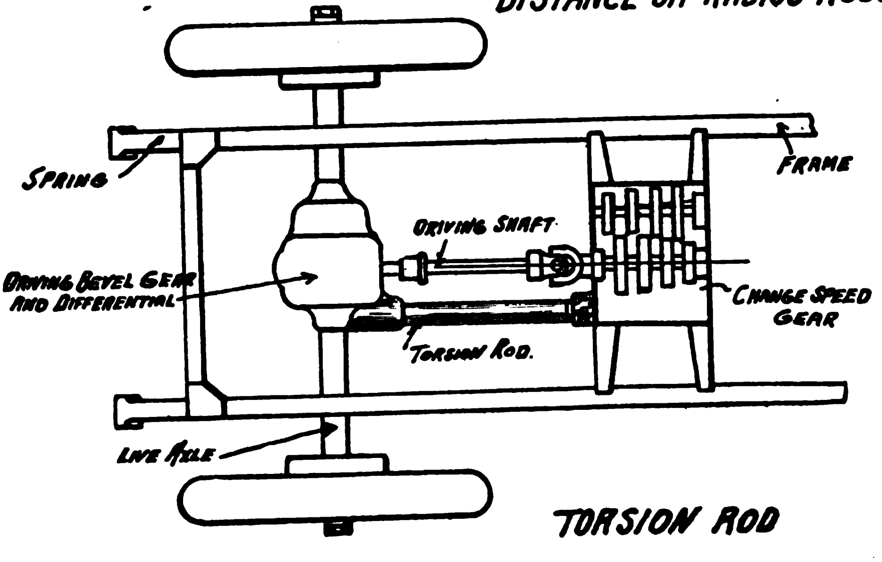
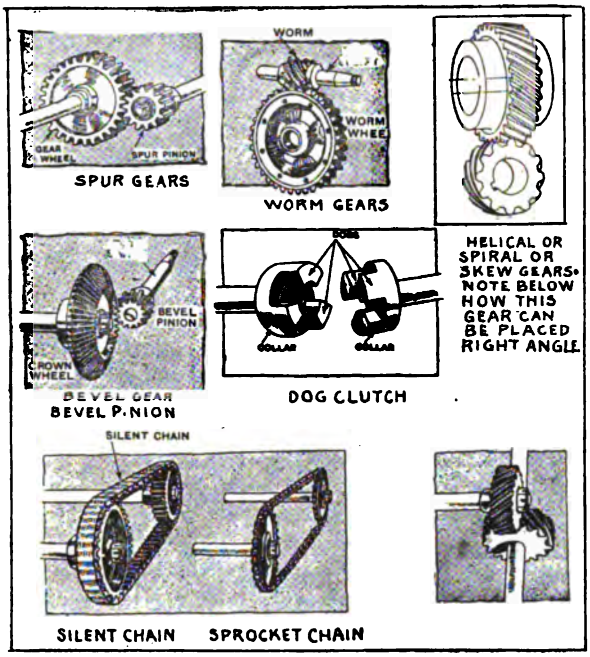


Fig. 3

CHART NO. 18—Explaining the Radius Rod, Torque Arm or Torsion Rod and Jack Shaft.

The advantages of this type of drive are that all of the moving parts are enclosed and protected from dust, and run in grease or oil, which means perfect lubrication.

The disadvantages of a divided or split rear axle, are the difficulty of keeping the bevel gears in exactly the correct relation to each other, because of the bending or springing of the axle, and the troubles that may come from the general weakness of a live axle. (This trouble has now been overcome. During the early days it was a source of bother.)



Note the different methods of driving. Bevel gears are used extensively on rear axle drive systems. Worm gears are also used on rear axles. Helical gears, silent chains are used extensively for magneto, electric starter and generator drives. Spur gears and the dog clutch are used in the gear box.

†Gears.

Bevel gears must be cut more accurately, and meshed more carefully, than spur gears. They are used principally for driving the rear axle (see page 32).

To transmit power without more loss by friction than can be helped, there must be as little play as possible without having the teeth bind.

†The setting of bevel gears requires careful adjustment, for if incorrectly meshed they will be noisy, and will wear rapidly.

‡**The worm drive gears** are fast becoming popular for rear axle drives, especially on commercial cars (see illustration above).

The spiral bevel, which is often referred to as helical gear is similar to the worm. The worm gear makes a wiping contact and the helical more of a rolling contact (see page 35). The "skew" gear is the same as the helical gear. This type gear is also used to drive ignition systems, etc.

Silent chains are used principally for driving generators, magnetos, cam shafts, etc. (see index).

Sprocket chains are used to drive the rear wheels in chain driven cars.

***Radius rods**: are mostly used, on commercial cars using double chain drive. They extend from a point along side of the frame in line with the jack shaft, thence to rear axle. Therefore they keep the chain at the proper tension and the distance from sprocket to sprocket the same, no matter how rough the road. A turn buckle is provided to adjust (see fig. 2, chart 13).

Many manufacturers however, have now discarded the radius rods entirely.

---

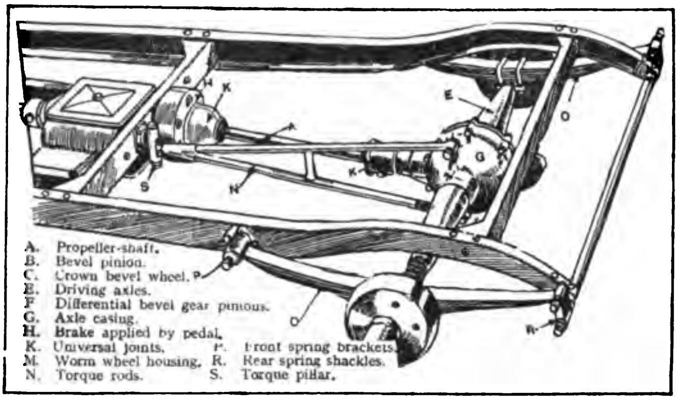
*Also called "strut" or "distance" rods. †See rear axles in repair subject and supplements.

†Bevel gears for final drive are of two types; the "ordinary bevel" and the "spiral bevel" (often referred to as the helical).

‡In principle the worm drive is a simple arrangement; the usual bevel gear and pinion are replaced by a specially-shaped hollow helical-toothed gearwheel and worm, the latter engaging in the teeth of the gearwheel, the axles of the two shafts being at right angles. When accurately made, worm gears run with great smoothness and silence. The worm may engage either from above or below the gearwheel. The angle of the worm and gear may be as much as 45 degrees. The worm (W) is made of hard steel and the wheel (B) of bronze.

The Torque Arm.

A torque arm ("torque" means turning movement or twist) is used on shaft driven cars. It extends from the cross member near the transmission to the housing on the rear axle, (construction varies).



A usual construction is shown in illustration. Note the **arm** (N), extending from the rear axle housing to a spring arrangement or torque pillar attached to a cross member, in line with the drive shaft (see illustration (S-N).

On the Hotchkiss drive the torque and drive is taken through the rear springs. The main leaf of each of these is made strong enough for this added duty, and the construction does away with torsion tubes, torque arms, and radius rods. On many cars the propeller shaft housing is made very heavy and acts as the torque arm.

If it were not for the torque arm, the revolving of the bevel gears would tend to revolve the rear axle housing, instead of revolving the axle shafts alone. While the construction of the rear axle would of course prevent this, there would be considerable play in the course of time, and the driving shaft might be strained and sprung out of line. The torque receives this strain, and protects the driving shaft. In other words it resists the torque of the rear axle when power or brakes are applied (see note on page 32).

Drive Reduction.

In all but racing cars, the speed of the crank shaft is reduced so that the road wheels turn once while the crank shaft revolves from three to four or four and one-half times with the high speed gear engaged.

On cars with single chain drive, this is done by having the transmission sprocket smaller than the axle sprocket.

If the reduction is to be three to one, that is, if the crank shaft revolves three times to once of the axle, the axle sprocket will have three times the number of teeth that the transmission sprocket has.

On shaft driven cars, the reduction is made at the axle drive gears. The gear on the axle is given as many more teeth than the pinion on the driving shaft as is necessary for the reduction that is required.

In the worm drive (see pages 32 and 35) the reduction is governed by the angularity of the teeth and not by the ratio. In other words the size of the worm could be changed without its changing the speed. (The angularity of course would have to be the same in both cases.)

To make the point clear as to just how the speed reduction is brought about in the worm drive, imagine the screw thread on a vise shaft which draws the jaws together. If that thread is coarse or has only a few to the inch, the jaws would move towards each other rapidly and of course would take some power to move it; if, on the other hand there were quite a number of threads to the inch the jaws would move slower but it would take less power to exert the same pressure.

The reduction on side chain cars is sometimes made at the bevel driving the jack, but usually at the sprockets.

Racing cars, or high powered touring cars for use over good roads, apply this reduction for the direct drive, but by the use of gears in the transmission may bring the speed of the wheels to the speed of the crank shaft, or even more.

When the "gear ratio" of a car is spoken of, it is this reduction that is meant. A car spoken of as having a "gear ratio of 3½ to 1" is one in which the drive shaft makes 3½ revolutions to one revolution of the road wheels on the high gear.

INSTRUCTION No. 3.

*STEERING, SPRINGS, BRAKES: Principle of Steering. Springs and Brakes.

Steering.

The principle: Pulling on one of the reins swings the horse to that side, in steering a wagon. The shaft or pole is attached to the axle, and the axle is pivoted to the king pin, all swing with the horse.

If you go straight ahead, the front and rear wheels of any vehicle move in straight lines. To make a turn to one side or the other, the front wheels are swung so that they are at an angle with the rear wheels.

Whenever the front wheels stand at an angle with the rear wheels, the vehicle will turn, and it will continue to turn until the front wheels are swung back to a straight line again.

In a horse-drawn vehicle, the front wheels are square with the axle, for wheels and axle swing together. (See fig. 1, chart 14.)

In an automobile, the front axle does not swing, but each wheel swings on a pivot at the end of the axle.

It would not be practical to steer an automobile as a horse-drawn vehicle is steered, for the axle would have to be very heavy to support the weight, and besides, it would be so hard to swing it that steering would be difficult. Another reason is that the body would have to be raised up high so the wheels could go under it in making a short turn.

A fixed front axle is always used on automobiles. The pivots on which the front wheels swing must be as close to the hubs of the wheels as possible, for the closer they are the less leverage there will be to overcome, and the easier it will be to steer, also less liable to break.

When a wagon or automobile turns a corner, it moves in the arc of a circle.

In a horse-drawn vehicle, the front axle, because it swings on the king pin, always points to the center of the circle (see fig. 1.) Notice that both wheels and the axle are perpendicular to the same radius of the circle in fig. 1.

The front axle of an automobile is fixed and cannot turn, and therefore only its pivoted ends point to the center of the circle (fig. 2.) Notice in fig. 2, that the axle does not move, but that each wheel moves.

When running straight ahead, the front wheels of an automobile are square with the axle. When turning, the front wheels are not square with the axle, but at an angle with it.

Because each wheel is square with its axle end, and both axle ends point to the center of the circle, each wheel is square, or perpendicular to, a radius of the circle. If both were perpendicular to the same radius, which they are not, the wheels would be parallel with each other.

Thus while the front wheels of a horse-drawn vehicle are always parallel to each other, the front wheels of an automobile turning a corner are not parallel to each other on the same radius.

*See pages 684 to 691 for "adjusting brake" and pages 691 to 698, "adjusting steering."

Sometimes the driver will notice he can turn his front wheels farther to one side than the other. This is due to two causes: (1) the steering knuckle arms are not properly lined up; (2) the tire of wheel may strike the steering knuckle thrust arm.

It is also noticeable that an automobile has a tendency to travel to the curb when running on the side of streets. This is due to the oval surface of street or if wheels are "cambered" too much, see page 688.

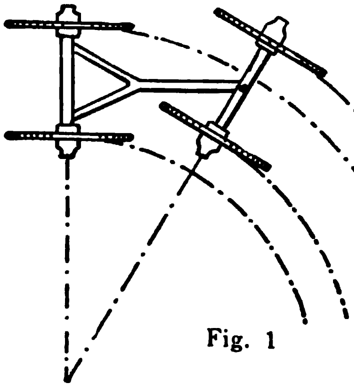


Fig. 1

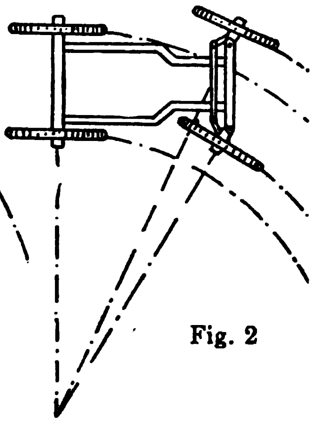
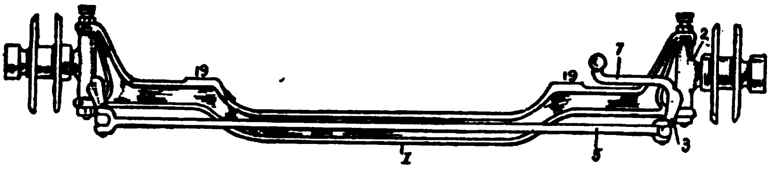


Fig. 2

Showing how a Front Axle of a horse-drawn vehicle gives the direction a horse-drawn vehicle runs.

Showing how the Front Wheels of an automobile give the direction the car runs.

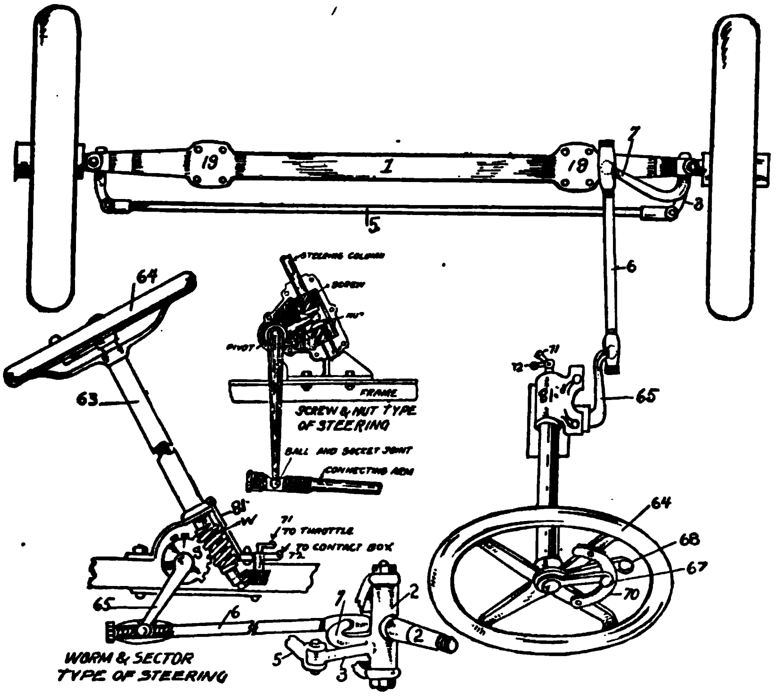


Front Axle.

1—Front Axle
2—Steering Knuckle
3—Steering Knuckle Arm
5— Rod
6—Steering Arm Thrust Rod
7—Knuckle Thrust Arm

Steering and Connections.

81—Steering Device Housing
63—Steering Column
64—Steering Wheel
65—Steering Arm
67—Spark Lever
68—Throttle Lever
71—Spark Lever, bell crank connecting through bevel to spark lever on Wheel
72—Throttle Lever, bell crank connecting with throttle lever thru a shaft, thru steering column, with throttle lever. 68
W—Worm Wheel
S—Sector.



Spark Lever (67) connects by a rod (which runs through the hollow steering post) and operates through bevel gears the Bell Crank (71), which in turn operates the timer on the engine or contact box on magneto, and advances or retards the spark in cylinders of engine.

Throttle Lever (68) connects by a rod, through bevel gears, and operates the bell crank (72), which in turn is connected by a rod with the throttle valve on the carburetor, and controls the speed of the engine by opening and closing a valve which admits or cuts off the gas supply.

CHART NO. 14—Explanation of Steering. Steering Gear, Parts and Connections. Spark and Throttle Lever System on the Steering Device.

The steering mechanism must be so arranged that the front wheels are parallel when the car is running straight ahead, but stand at an angle with each other when turning a corner.

Each of the pivoted axle ends (2), which are called **steering knuckles,** has a **steering arm** (3 and 4) projecting from it.

The ends of these two arms are connected by a rod called a **drag link or tie rod** (see fig. 5). When the drag link is moved endways, both wheels move with it.

The two steering arms are not parallel, but incline a little toward each other. If they were parallel, the two wheels would be parallel, no matter how the drag link was moved. As they are not parallel, moving the drag link moves one of the wheels through a greater angle than the other, depending on the direction the drag link is moved.

The old style of steering arrangement was a lever and rod running from the driver's seat to the steering knuckle. This old style arrangement would reverse and was unreliable. In striking stones or ruts in the road the wheels could be thrown from side to side, and the driver would be obliged to grasp the steering lever firmly to keep the car straight.

A bad place in the road might throw the handle out of his hand. While this is good enough for a light slow speed runabout or electric vehicle, it would be very serious with a large, heavy automobile.

A device must be used that will swing the front wheels when the steering wheel is turned, but that will keep the front wheels steady, and prevent their moving the steering wheel.

This is called an *irreversible steering gear, and while it is made in many ways, the chief types are the **worm-and-sector,** and the **screw-and-nut or worm-and-nut,** all shown in chart 14.

The worm-and-sector type consists of a worm (w), which is attached to the lower end of the rod moved by the steering wheel (64). Meshing with the worm is a sector wheel (s), so that turning the steering wheel turns the worm, and moves the sector wheel.

Attached to the sector is an arm (65), which is connected to the steering knuckle by the connecting arm or rod (6). The end of arm (65) and arm (7) are ball shaped, and fit in a socket on the end of rod (6) so that the fit is always tight, whatever the angle between the arm and the connecting rod may be. The socket is often movable, with strong springs on each side to hold the parts together, and to take up some of the shocks of the road.

The worm and sector are contained inside a metal case to protect them from dust, and to hold the grease in which they are packed.

The worm-and-nut type steering gear shown in chart 14, has a nut through which a worm passes. Instead of a "sector" the nut is used. The worm is fastened to steering rod. Turning the steering wheel moves the nut up and down.

One arm of a lever fits in a groove on the outside of the nut, and the other end is connected to the steering knuckle by a connecting rod. Steering gears are usually built so that wear can be taken up.

The breaking of any part of the steering connections is more likely to cause a wreck than the breaking of any other part of the car, and must be watched carefully. The parts must be kept tight enough to prevent play, but must not be so tight as to make steering hard. All parts must be kept lubricated, and the connecting rod, tie rod and knuckle joints are usually packed in grease and protected from dust by leather pockets that buckle over them.

***A steering gear** is said to be irreversible when an ordinary road wheel impact will be insufficient to turn the steering wheel. This is simply a question of reduction between the steering worm and gear, the greater the reduction, the less reversible the system and likewise the slower the motion of steering the road wheels in relation to the movement of the steering gear. Therefore a heavy car will be normally less reversible than the steering gear on a lighter car.

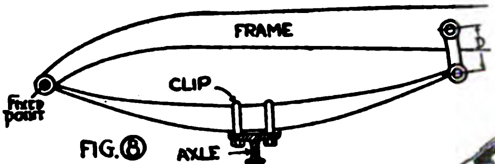


FIG.⑧

Half Elliptic Spring-Front.

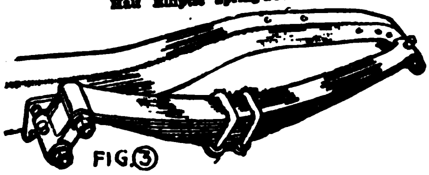


FIG.③

Half elliptic rear spring anchored on pins on end of frame.

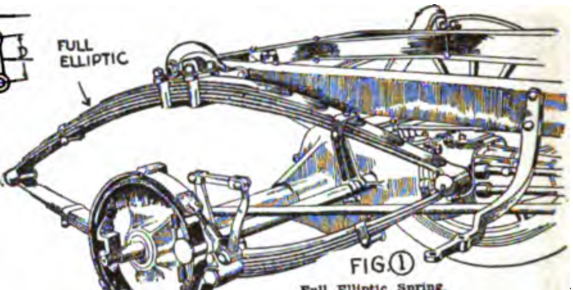


FIG.①

Full Elliptic Spring.

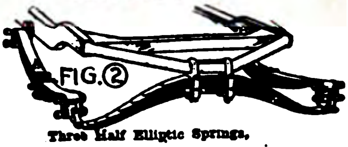


FIG.②

Three Half Elliptic Springs.

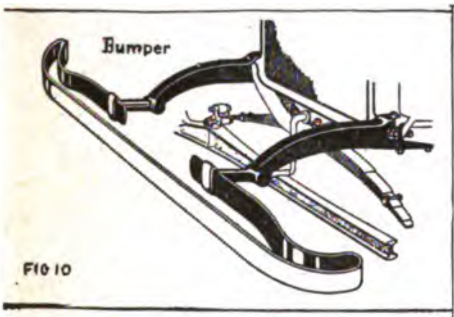


FIG 10

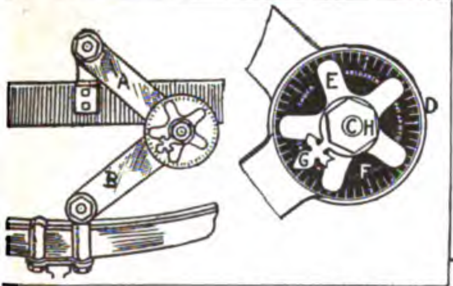
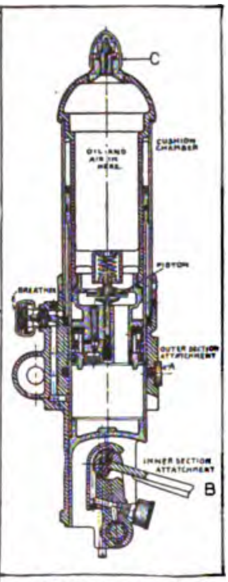


Fig. 8. The Hartford Friction Type Shock Absorber.

Briefly describing the Hartford friction type—consists of a single arm, A, and a double arm, B, frictionally joined by bolt, C, and adjusting nut, H. Arm A works between the two members of arm B, giving a straight up-and-down movement, and the arm A being made of spring steel allows for any side-sway. The arm A carries a flanged cover, D, forming a cup-like space on each side. In these spaces are placed the friction plates, which are self-lubricating and highly impervious to wear. By screwing sufficiently on adjusting nut, H, any desired degree of friction may be obtained.

An adjustment dial, F, and indicator, G, provide means of securing the correct tension for the car. A spider compensating spring, E, takes up any little wear automatically, keeping the frction uniform after the adjustment has been made.

The arms A and B are joined to the frame and axle by two frictional joints, which also can be regulated.



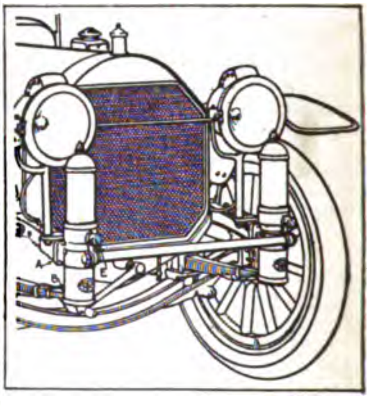


Fig. 7: Air Spring or Plunger Type Shock Absorber.

It consists of an air chamber made up of two sections, one of which telescopes into the other. The outer section is attached to a bracket on the frame of the car, (A). The inner section is attached to one end of one of the springs, (B).

The chamber is partly filled with oil, through the filling-plug hole under the cap (C). The filling-plug is fitted with an ordinary Schroder tire type of air valve through which the chamber may be charged with air at any desired pressure, by means of an ordinary tire pump.

The oil in the chamber seals the packings of the telescoping joint and prevents the air from leaking out.

The mechanism inside the chamber is a small oil pump which is worked automatically by the up and down flow of oil past the flat piston (D), whenever the Air Spring is compressed or extended. A trifling amount of oil which is always passing by the packings when in motion keeps them thoroughly lubricated. The surplus drains into a collecting pocket, and the automatic oil pump delivers it back into the cushion chamber.

The oil passage surrounding the piston D is purposely restricted in order to retard the quick reaction of the spring, and thus prevent the disagreeable and dangerous catapult effect that is so apt to throw passengers from their seats when the car is passing over "thank-you-ma'ams," car tracks or other road obstructions.

All of the time that the spring is in action, air is being drawn in through filtering material in the "breather" E, and blown out through suitable passages in such a way as to keep the telescoping joint free of dust and dirt.

CHART NO. 15—Springs. Shock Absorbers.

*Springs—see chart 15.

All vehicles intended to move at more than a very slow speed must be provided with springs. Springs not only protect the occupants from the vibrations of a rough road, but also keep the machinery from being shaken to pieces.

The size and strength of the springs depend on the weight of the vehicle. Springs that are too weak will not give sufficient protection and if they are too strong they will not have enough resiliency.

Types of springs in general use are: Full elliptic, three-quarter elliptic, half elliptic and cantilever.

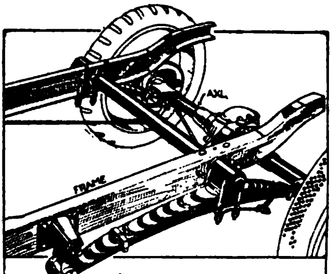


FIG. ④ Compensated cantilever springs

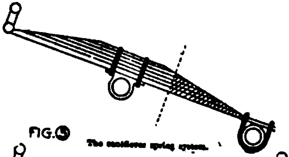


FIG. ⑤ The cantilever spring system.

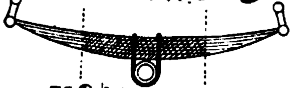
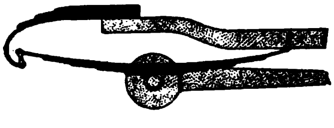


FIG. ⑥ Semi-elliptic spring.

FIG ⑨ A system of transverse rear springing which provides suspension at a central point on the frame, thus relieving the frame of twisting stresses.



The three-quarter elliptic rear spring. A type seldom used.

The full-elliptic was formerly used on a great many cars for the rear, as per fig. 1. In some instances it was used in front.

Other types of rear spring suspension are shown in figs. 1, 2 and 3, also the cantilever, fig. 4.

The cantilever spring system (fig. 4) is probably the most popular present day practice. The illustration shows how it compares with the ordinary half-elliptic principle shown in fig. 3.

In the cantilever spring the forward end is shackeled and the axle attached to the rear end. The center of the spring is attached to a trunion or bearing on the frame. Thus the spring has a certain amount of movement about its center. One good feature of this form of spring is that it reduces the unsprung weight of axle. The shaded parts of the respective springs show the comparative amount of unsprung weight. In the cantilever form of spring the heaviest part of it is supported by the frame.

The half-elliptic spring (upper fig. 8) is used to a great extent for the front.

*Breakage of a spring means breakage of one or more of the leaves. Breakage almost always occurs in the expansion that follows a heavy compression, and not during the compression. In other words, it is the rebound that breaks the spring.

Because the leaves slide on each other, they will wear and squeak if not properly lubricated.

To lubricate between the leaves it is necessary to relieve them of the weight they carry. This may be done by jacking up the body, or taking the springs apart, and spreading heavy grease or graphite on the leaves. This is quite a job and is seldom done (also see index "lubricating springs.")

Shock Absorbers—see chart 15.

As breakage will come during a rebound, devices called shock or jolt absorbers are attached to the springs to check their up movement, also to prevent jolting on rough roads.

There are two types of shock absorbers in general use; the friction type and the air or plunger type.

The friction type is shown in fig. 8. All these movable frictional parts offer a constant resistance to the vibration of the spring both ways, and it is easy to see that when the wheel strikes an obstruction, the arms come together, but instead of the flying back, as does the free spring, it is retarded by the friction and moves gradually to its normal position, since the friction is always the same, while the tension of the spring diminishes as it approaches its normal position.

The air or plunger type is shown in fig. 7 chart 15. There are other types of plunger type shock absorbers, but the two mentioned are most popular.

---

*See repair subject for repairing springs.

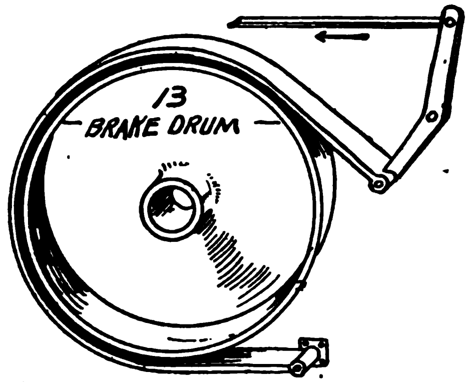


FIG.1 SINGLE ACTING, BAND BRAKE EXTERNAL TYPE.

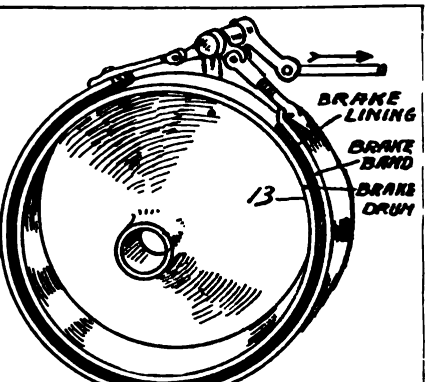


FIG 2. DOUBLE ACTING BAND BRAKE. EXTERNAL TYPE

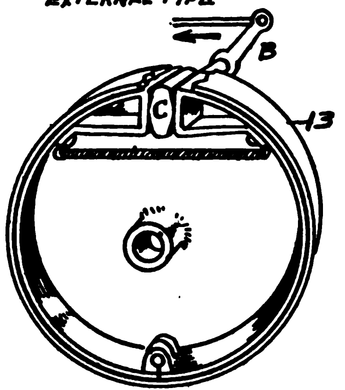


FIG 3. INTERNAL EXPANDING DOUBLE ACTING, BAND BRAKE.

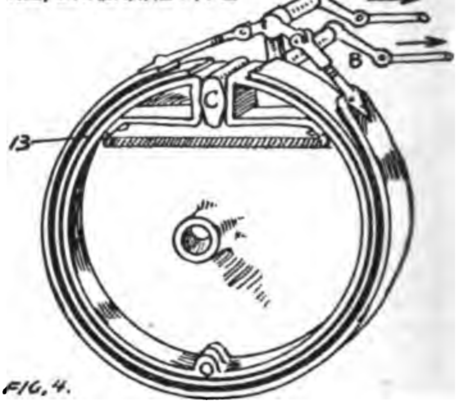


FIG. 4.
COMBINATION OF INTERNAL AND EXTERNAL. DOUBLE-ACTING. BAND BRAKE.

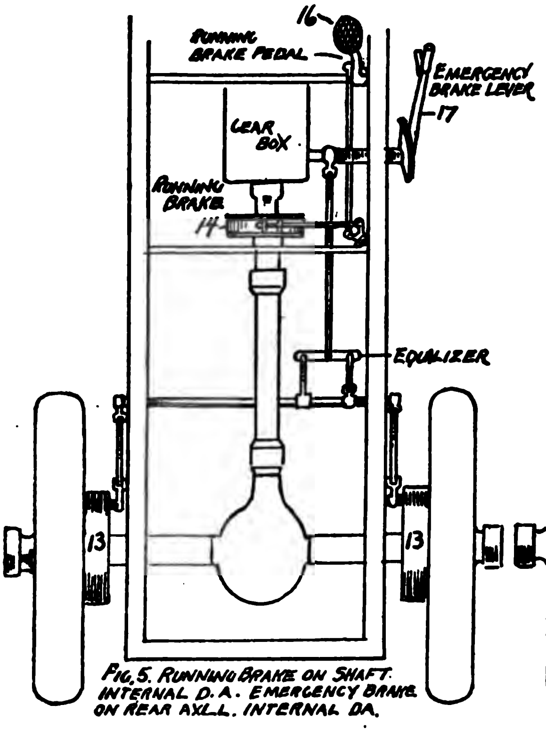


FIG. 5. RUNNING BRAKE ON SHAFT INTERNAL D. A. EMERGENCY BRAKE ON REAR AXLE. INTERNAL DA.

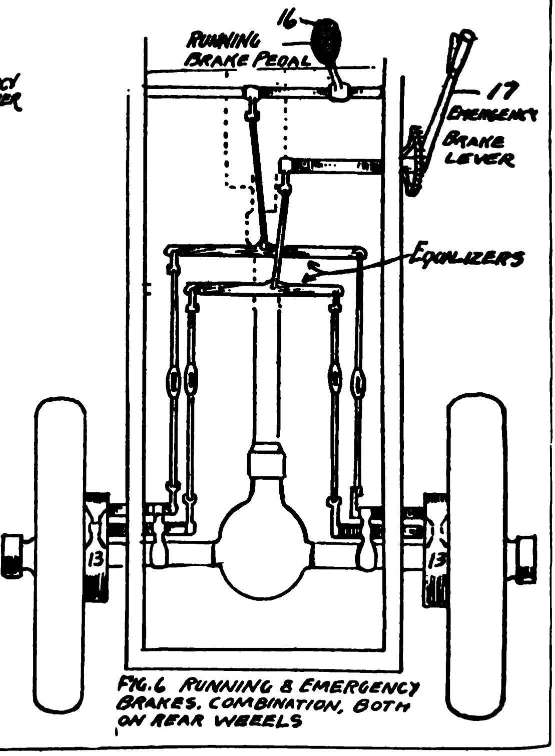


FIG. 6 RUNNING & EMERGENCY BRAKES. COMBINATION, BOTH ON REAR WHEELS

HART NO. 16—Brakes and Brake Systems. Explanation of the "Running" or Foot Brake and the "Emergency" or Hand Brake. The hand brake usually operates the internal brake inside of the rear brake drums or the brake on transmission shaft. The foot brake operates the external band

*Brakes—see chart 16.

An automobile is equipped with brakes, **usually on drums on the rear wheels,** so that its motion may be checked or stopped when running or so that it may be held on the side of a hill.

In a horse-drawn vehicle with steel tires, the brake shoes press directly on the tires, but as this would quickly ruin rubber tires, brakes for automobiles are of other types.

Because of the weight of an automobile, its brakes must be powerful in order that it may be stopped suddenly when necessary.

Practically all **automobiles are fitted with two sets of brakes,** called the running service or foot brake and the emergency or hand brake.

***The foot brake** is applied by pressing on a foot pedal (16) and is the one most in use because of its convenience, and because it is used most when running. The foot brake is also called the **service** brake.

The usual method of connecting the running, service or foot brake is by a contracting band on the **outside** of the brake drum on rear wheel hubs called the external contracting band brake.

The emergency or hand brake is usually applied by a lever (17) at the side (or center) of the driver's seat, so placed that he may apply his whole force to it. The emergency brake is seldom used while running. It is usually applied when the car is left standing, in order to keep the car from rolling down an incline. It connects in almost every instance with the internal expanding brake **inside** of the brake drum on rear wheel hubs, but occasionally will be found connected by a contracting band over a drum mounted on the main transmission shaft.

The foot brake pedal is the right pedal on most all cars, see "operating a car."

Types of Brakes.

Therefore summing up the types of brakes we might say there are but two distinct types in general use; the **external contracting** and the **internal expanding** type.

The external band brake is a flexible steel band faced with an asbestos composition—called Raybestos or Multibestos.

Setting the brake causes friction between the brake drum and the linings, hence the use of asbestos composition.

Band brakes are of two kinds: Single acting and **double acting,** the latter being an improvement over the former.

The single acting band brake (fig. 1, chart 16) only binds when the drum is revolving in one direction, having very little grip when the drum is revolving in the same direction in which the band is being pulled. This form is going out of use for automobiles, for it cannot be depended on to hold the car from running down hill backward.

The double acting band brake (fig. 2), is taking its place, for it holds with the drum revolving in either direction. In this form, both ends of the brake are attached to the lever or pedal, and so arranged that while one end is being pulled in one direction, the other end is being pulled in the opposite direction. This binds on the drum so tightly that it may be depended on to hold the car in any position.

---

*The running brake is now known as the "foot brake." The emergency brake is now properly called the "hand brake."

See repair subject for repairing, relining and adjusting brakes (see index).

The brake shoe is a band that may either be drawn around the outside of the drum, called the **external band brake,** or expanded within it so **that** it bears against the inside wall of the drum, called the **internal expanding brake.** Sometimes the internal brake is made of **metal.**

The external type of brake is usually of the **double acting** band **brake** type, and is always placed on the outside of the brake drum attached to hub of rear wheels.

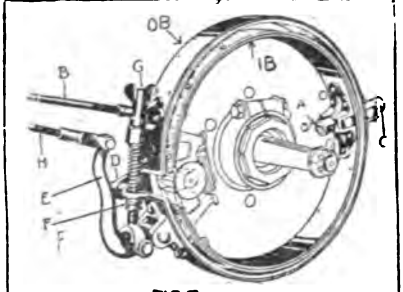


FIG 7

Fig. 7.—A combination of an internal expanding and external contracting brake system on brake drum of rear wheel hub. OB is the outer or external and 1B is the inner or internal. B is the hand brake rod operating the internal brake. H, foot brake rod operating external brake. **Adjustment of external brake** is made at F, G and C. **Adjustment of internal** or hand brake is at A. It is turned up or lowered so as to have 1-64 inch clearance between brake drum and brake. (See page 691 for "adjusting brakes" for further information.)

The internal expanding brake acts on the inside of drum (1B, fig. 7) and may be a metal shoe or metal faced with **asbestos** composition, but more frequently a **band** faced with an asbestos friction composition.

The internal band brake formerly consisted of two shoes of metal, but the modern form is shown in fig. 4, chart 16. When the lever (B) is raised the wedge (C) forces the internal brake against the inside of the drum. This brake shoe is lined with Raybestos or some similar material.

A combination of internal expanding and external contracting brakes are shown in fig. 4, chart 16. Lever (A) operates the external brake and lever (B) the internal brake. (See also fig. 7 this page, and page 689).

Brake Connections.

There are two methods usually employed for the **hand brake**; (1) by connecting hand lever with the brake on transmission shaft; (2) by connecting with the internal expanding brake inside of drums on the rear hubs. This latter method being the one in general use.

The **foot brake** on most all cars connects with the external band brake on rear brake drums. It is used most and requires more attention.

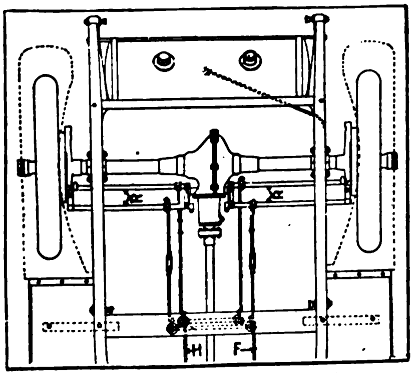


Fig. 8.—Note modern method of connecting the two brakes in rear.

Brake Equalizers.

When the foot brake pedal or hand brake lever is applied, the pull should be the the same on each brake on each wheel. If one brake rod is longer than the other the brake effect is not equal on both wheels, and this has a tendency to make the car skid.

To overcome this, a brake **equalizer** is used, the principle of which is shown in figs. 5 and 6, chart 16, and page 204. This **is** a rather crude illustration in chart 16, but it clearly explains the principle. In chart 100 the idea is more clearly explained. The brake equalizer, however, **has** been greatly improved as shown in illustration, fig. 8. Also page 32. Instead of an equalizer, the rods (R) are placed in bearings and the rod (F) connects with foot brake and rod (H) with the hand brake.

If a brake squeaks, it is an indication that it is dirty and needs cleaning The dirt clogs the pores in the surface of the lining and glazes it over. Gasoline or, better, kerosene will remove the dirt. The wheel should be removed and the linings cleaned with a stiff brush, such as a tooth or nail brush.

INSTRUCTION No. 4.

AXLES, DIFFERENTIAL OR COMPENSATING GEARS, BEARINGS: Front Axles. Rear Axles. The Differential: principle and application; the bevel and spur gear. Bearings: ball and roller.

Front Axles.

The front axle of a modern car carries most of the weight of the engine, and must at the same time withstand the shocks and jars that it receives through the steering wheels; it must therefore be strong and stiff.

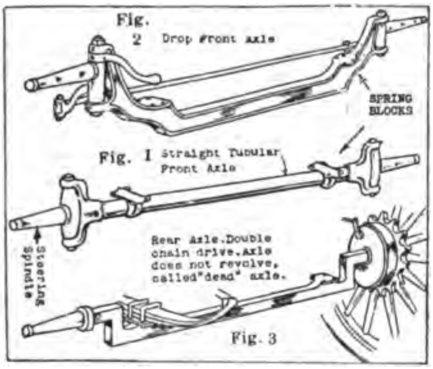


Fig. 2 Drop front axle
SPRING BLOCKS
Fig. 1 Straight Tubular Front Axle
Steering Spindle
Rear Axle. Double chain drive. Axle does not revolve, called "dead" axle.
Fig. 3

Front axles are of two types: tubular and **solid** (figs. 1 and 2). Formerly axles were made of heavy steel tubes, but steel drop forgings with a cross-section of the form of the letter I, is considered to give better results.

The center of the axle is usually bent down, so that it is the lowest point of the car except the wheels; this is done in order to protect the mechanism from being struck by high spots in the road. A rock or stump standing up high enough to hit the fly wheel, will first strike the axle, which is strong enough to withstand a blow that could easily damage the engine.

The steering spindles are that part of the front axle on which the front wheels revolve and are made of nickel steel, heat treated. The steering spindles are sometimes fitted with either roller or ball bearings. The **steering knuckle** is that part which fits into the yoke of the axle. The steering arm (65) of the device (page 24) connects with the steering knuckle thrust arm (7), and movement of steering wheel, then guides the direction of the wheels.

*Rear Axles.

There are two types of rear axles; the dead axle and the live axle.

Dead axles are stationary, with the wheels running free on the end of axle, and are usually made as shown in fig. 3. The wheels are usually revolved by chain and sprocket (see charts 11 and 13), and there is no provision in axle itself for driving wheels.

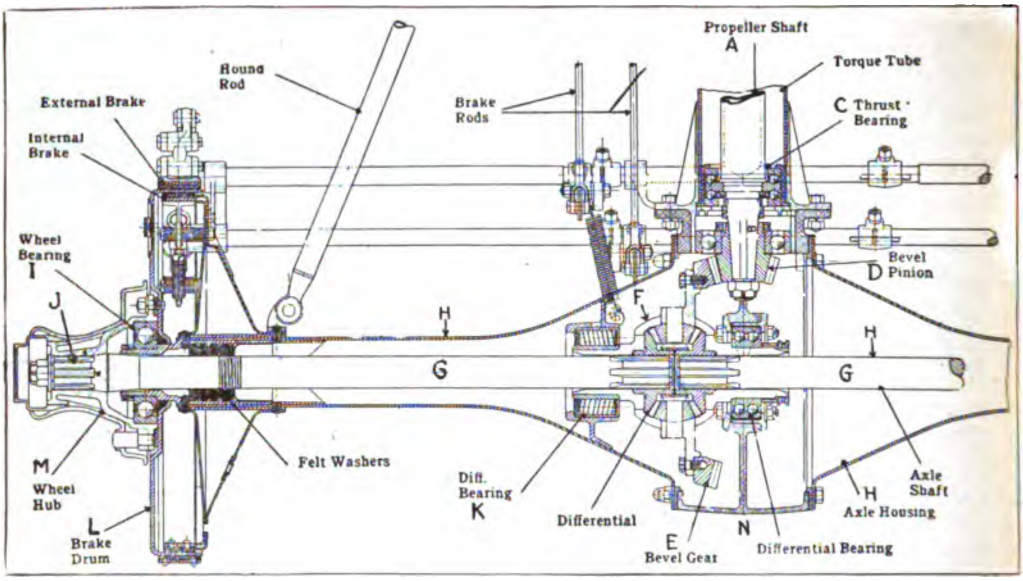
Live rear axles is the name given to axles that revolve with the wheels, and are known as **plain** live axle, **semi-floating** axle, **three-quarter floating** axle, **full-floating** axle.

A live axle on any type is made in **two sections**, the differential being placed between its inner ends, this makes it necessary to support the axle parts in a strong housing and to brace it, in order that the parts of the axle do not sag or get out of line.

The axle is contained in a housing which is a metal cover entirely surrounding it; the differential gear, which is in a smaller housing of its own, being also inside of the axle housing. The housing extends to the wheels,

---

*See index for "axles, front and rear, adjusting, removing," etc.
See index for "Standard Adjustments of Leading Cars" for type axle used on different cars.



Construction of a Rear Axle—(Marmon).

Illustrating rear axle complete with bevel driving gear (E). Differential (bevel pinion type). The actual driving axles do not support any dead weight. The road wheels run on ball bearings (I) carried on the outer sleeve or casing of the axle. The details are as follows:—(A) propeller shaft connection. (B) driving pinion shaft. (C) ball thrust bearings. (D) bevel driving pinion. (E) large bevel. (F) differential gear. (G) half of driving axle. (H) tubular outer casing or sleeve. (I) ball bearing for wheels. (J) driving ends of axle (squared or keyed). (K) roller bearings in differential case, (L) drum of internal and external brake. (M) hub of detachable wire wheel. (N) casing enclosing bevel gear and differential.

Note—The power is transmitted from driving bevel (D) to large gear (E)—this being bolted to the case of the differential (F)—thence by the inside pinions to each half of driving axle. It is usual to "anchor" the outer casing enclosing the differential gear to the chassis by means of torque or hound rods bolted to the upper and lower points of the gearcase which counteract the tendency for the whole casing to twist round from the reaction of the driving effort. On some cars the rear springs are made to serve as torque rods.

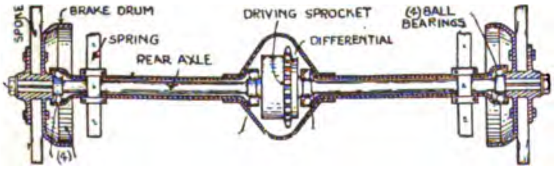


Fig. 3—A single chain driven live rear axle—now extinct.

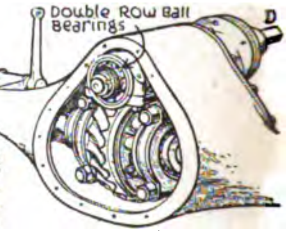


Fig. 4—Over-type worm drive rear axle with inspection cover plate removed exposing the gear.

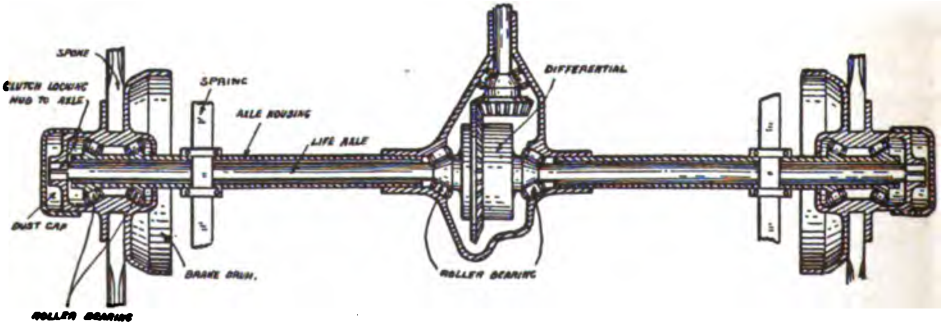


Fig. 2—Full floating live rear axle with roller bearings.

CHART NO. 17—Rear Axles.

and is enlarged at those points to take the ball or roller bearings. These bearings run between the axle and the inner side of the housing, or as shown in figs. 5, 6 and 7.

There are also bearings at the inner ends of the two parts of the axle, close to the differential. The axle housing of this type must be heavy, as it supports the weight of the car.

Types of Rear Axles Explained.

Plain live axles: have shafts supported directly in the bearings at center and at ends, carrying a differential and road wheels. This type is now practically extinct.

***Full floating type of rear axle:** the weight is taken from the axle, and supported on the housing through which the axle passes (fig. 5).

The hubs of the wheels are outside of the housing, and the bearings are between the inside of the hub and the outside of the housing (fig. 5).

The axle passes through the housing, and the ends that project are square; over these square ends fit caps that screw or are bolted to the outside of the hub. Thus when the axle revolves, the caps transmit the movement to the wheels. As the wheels run on the housing, the housing supports the weight, the axle serving only to turn the wheels. By removing the caps, the parts of the axle may be drawn out without removing the wheels, which hold up the car whether or not the axle is in place.

By jacking up the car to take the weight from the wheels, they may be drawn off the housing. The live axle is not continuous, but is **divided** in the center (see chart 18).

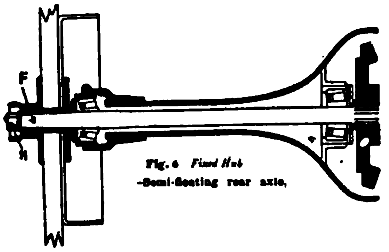


Fig. 6 Fixed Hub -Semi-floating rear axle,

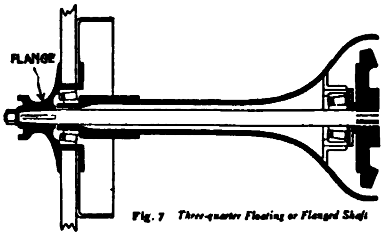


Fig. 7 Three-quarter Floating or Flanged Shaft

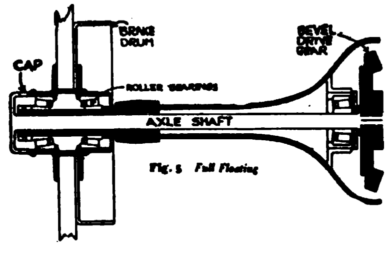


Fig. 5 Full Floating

In the "semi-floating" type, more properly called the "fixed hub" type (see figure 6), the driving shafts turn freely within the housing. At their outer ends they are **fixed** in the hubs of the wheels and carry the bending stresses as well as the torque. The hub of wheel in figure 6 is fitted to shaft with Woodworth keys and nut (N) which serve to secure wheel to shaft. Hub cap is merely a protection to end of hub.

In the "three quarter floating" (figure 7) or better the "flanged shaft" type, the housing extends into the hubs of the wheels as in the "full floating" type, but the ends of the driving shafts are connected rigidly by flanges with the wheels so that the shafts take almost all the bending stresses and all the torque. In the flanged shaft axle, especially when **only one bearing** is used under the center of the wheel, the stresses are quite similar to those in the fixed hub type.

In the "full floating" type of axle (figure 5) all the bending stress due to static force and skidding force is carried by the housing. The driving shafts turn freely within the housing and bear only the "torque" or stress of turning the wheels. The shafts are said to float within the housing.

In the full floating axle the shafts can be more easily removed for repairs. This is an advantage. It is necessary to make the full floating somewhat heavier than the fixed hub type for the same capacity.

---

*See also index for "axles, full floating;" and "removing axles." see page 669.

In the full floating axle the entire differential can be removed by unscrewing 4 bolts (after cover plate is removed). In the ¾ floating, two gears must be removed first, before differential can be taken out, and in the semi-floating, the entire housing must be removed from car.

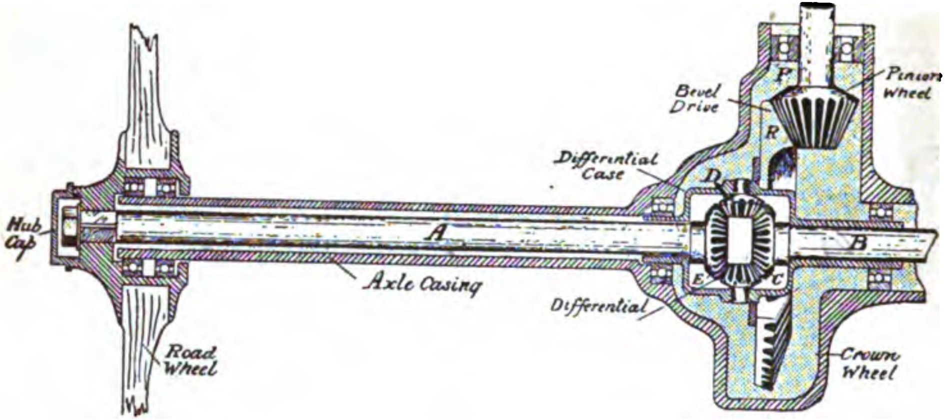


Fig. 1...Expaining how the bevel gear type of differential is connected to the bevel drive (R) gear on the rear axle inside of the housing. A—is the floating type of rear axle which is not solid but split in the center. E—is a small bevel gear on end of axle which meshes with small pinions. D—pinions revolve on a spindle which is attached to a housing cast or bolted to the large bevel drive gear R. R—is the large bevel drive gear which is driven by the drive pinion P. P—is the drive pinion connected with the drive shaft. B—is the other half of the rear axle which has on its end the bevel gear C. C—meshes with the gears D just the same as the other half of axle.

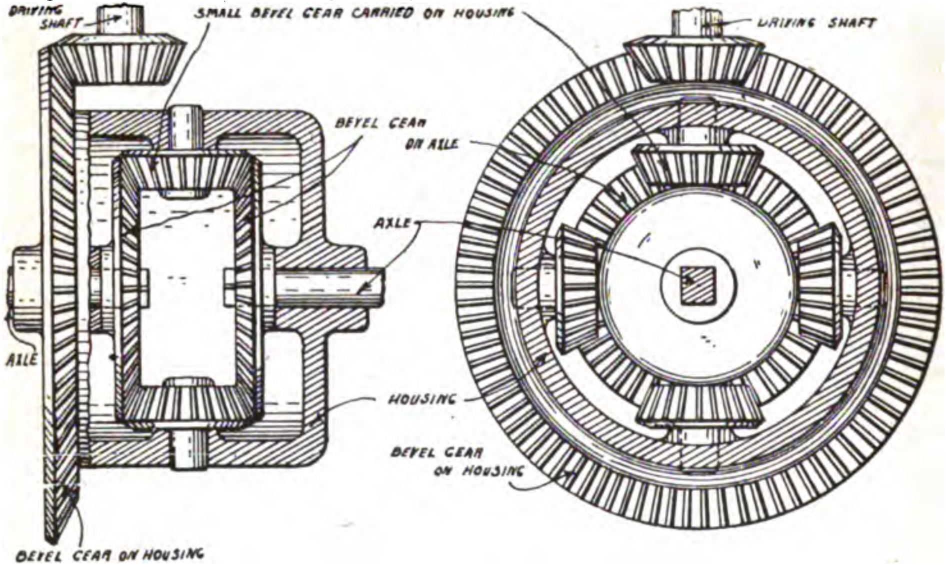
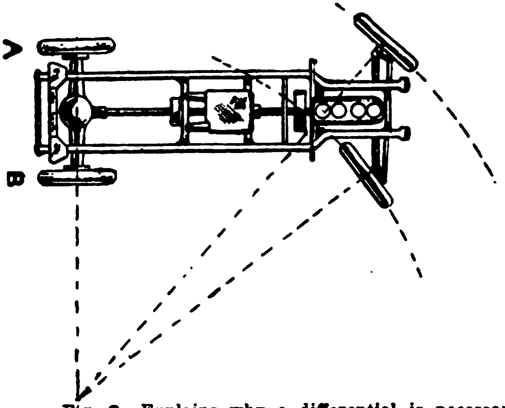


Fig. 2. Shows the construction of the bevel gear type of differential.



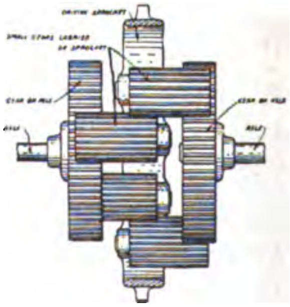


Fig. 4. A spur gear type of differential.

Fig. 3—Explains why a differential is necessary. In turning a corner the outside wheel (A) must turn faster than the inner wheel (B). Therefore a gear to allow for this compensation of the variation is embodied in the differential gear.

CHART NO. 18—Differentials: The Bevel Gear Type and the Spur Gear Type. Differentials are sometimes called Compensating Gears.

Types of Rear Axle Drive Gearing.

The different types of live rear axles can be driven by **bevel gears, spiral or helical bevel gear, worm, double reduction gear or single chain.**

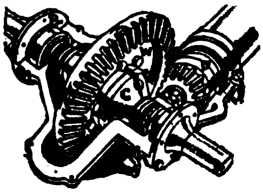


Fig. 1.—Straight tooth bevel gears.

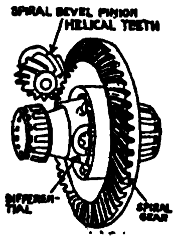


Fig. 2.—Spiral tooth bevel gears.

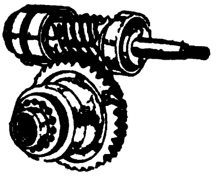


Fig. 3.—The worm type of gear. The worm (W) can be overhead or underneath worm wheel (B).

The straight tooth bevel gear is the most popular type for pleasure cars.

The power from the engine is transmitted at right angles to the rear axle and the road wheels by means of a **bevel gear.** This consists of a small bevel pinion (P) meshing with a similarly toothed wheel, but much larger in diameter and known as the axle drive bevel gear (W). The ratio of the diameters of these gears ranges from 3½ to 1 to 4½ to 1, and this ratio determines the "high gear" or direct drive of the car. The conical shaped box or casing in the center of the drive gear contains the differential gear. The thrust or pressure between the two bevel gear wheels is very severe and this thrust-friction is taken by the ball bearings which are shown at "C," top of page 32.

The spiral or helical tooth bevel gear is also being used on pleasure cars to a considerable extent. This type if accurately made is very silent.

In a straight tooth bevel gear any given tooth goes in and out of mesh at one time along its entire length. In the helical bevel the meshing starts at one end of the given tooth and gradually moves towards the other end. Therefore, two helical teeth are in mesh at all times.

The worm and worm gear is used quite extensively on electric and commercial cars or trucks where a large reduction of gearing is necessary. It is replacing the double chain drive. It is made with the worm **overhead,** or **underneath.** The worm drive is very quiet and efficient. Worm gearing is destined to become popular on the gasoline pleasure car also. (See fig. 4, page 32, and page 14.)

Double reduction gearing refers to the type formerly used on the Cadillac. See index for "two speed rear axle."

Single chain drive is now obsolete. An illustration is shown in chart 17, fig. 3, page 32.

***The Differential**—also called Compensating Gear.

Purpose: It is necessary to fit an automobile with a differential or compensation gear, in order that the rear wheels may revolve at different speeds when the car turns a corner, while at the same time both are being driven by the engine. This gear is automatic, and operates according to the resistance of the road against the wheels.

Principle: There is more resistance to the turning of the **inside** wheel than the **outside** wheel, when car is turning, consequently the outside wheel may revolve faster. It is necessary for the outside wheel to revolve faster, because it has a longer distance to travel than the inside wheel. The same applies to a wagon, but the wagon wheels run free on the axle, therefore a compensating device is not necessary.

See fig. 3, page 34, and note that if car is turning to the right, the wheel A, must revolve faster than wheel B. Also refer to fig. 1, and note that axle shaft A being attached to wheel A, must revolve faster than axle shaft B, when turning to the right and vice versa if turning to left. Therefore, to compensate for this difference in speed of the two wheels and axle shafts, bevel gears (E and C fig. 1) are placed on the ends of the axle shafts, which mesh with the small bevel gears, called **compensating gears** (D, fig. 1), which are free in bearings on housing or differential case attached to drive gear R, fig. 1.

As long as car travels straight ahead and resistance of both rear wheels is the same, these gears (D) do not turn, but when car turns, then greater resistance is offered to the inside wheel, therefore, the **compensating gears** (D) turn, permitting the outside wheel to revolve faster than the inside wheel. In fact, the inside wheel could be stationary or revolve backwards if necessary.

A study of figs. 1 and 2, page 34, will make this principle clear. Note drive of rear axle is through the drive pinion P, to gear R, (fig. 1), thence through differential case attached to it, then **compensating gears** D, to bevel gears (E and C) attached to ends of the rear axle shafts.

When a double chain drive is employed, the differential is placed on the jack shaft as shown in fig. 1, page 20. The jack shaft is in two parts similar to axle, fig. 1, page 34.

*See pages 669 and 782 "Pointers on Removal of Differential."

*Bearings.

Every part of the car that moves with a rotary, sliding or other motion is supported in bearings, which together with proper lubrication reduce wear and friction.

There are three different types of bearings in general use; the **plain, roller** and **ball** bearings.

Bearings are called upon to do two kinds of work; to take a **radial** load or a **thrust** load or a **combination** of both.

A radial load is load or pressure perpendicular to the shaft supporting the load. For instance, the wheel bearings of an automobile, when running on a perfectly level road are subject to radial loads.

Thrust load is a load or pressure parallel to or in direction of the shaft. When the automobile strikes a curve a thrust load is imposed on the bearings in the wheels—that is, to the side or endwise.

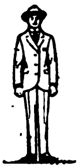


Fig. 8 -PURE RADIAL LOAD

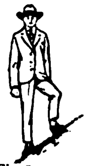


Fig 9 -COMBINED RADIAL AND THRUST LOAD

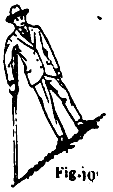


Fig. 10

AN AWKWARD WAY OF RESISTING COMBINED END THRUST AND RADIAL LOAD

†**We might illustrate the relation between thrust and radial loads in this way:** A man could be considered as being subjected to pure radial load when walking on an absolutely level surface, fig. 8, but when this man walks along a hillside, without either ascending or descending the hill, as illustrated in fig. 9, he is subjected to a combination of radial and thrust load; the thrust load having a tendency to push him down the hill.

If a straight roller were called upon to take a thrust load as well as a radial load, it might be compared to the man in fig. 10, he would need a crutch to prevent his toppling over. Therefore a ball thrust bearing (fig. 7) would be necessary at end of the straight roller bearing, per fig. 12.

Plain bearings are usually on the main crank shaft, cam shaft and connecting rods of an engine and take a radial load.

Plain bearings can also be designed to take thrust loads.

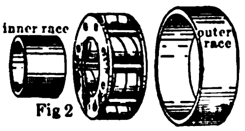


Fig 2

Roller bearings are used in the wheels, rear axle, transmission and other places and when **straight,** as per fig. 2, they can only take a radial load. The roller itself runs over an inner race and inside of an outer race, case hardened.

When a roller is tapered, it runs over a cone type hardened race (fig. 1), and inside of a outer race, arranged as per fig. 11 and page 687. This type of roller bearing will take a radial and a thrust load without the use of a separate thrust bearing.

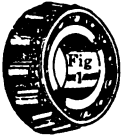


Fig 1

The groove in the race and roller, **fig. 11,** take the thrust load as well as the cone shape of race.

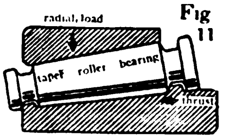


Fig 11

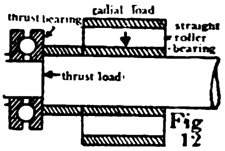


Fig 12

A straight roller bearing, to take a thrust load as well as a radial load, would require a separate thrust bearing, fig. 12 and fig. 9, page 676.

Ball bearings are also used on the wheels, rear axle, transmission and other places. They are divided into three general classes; **cup and cone, annular and thrust.**

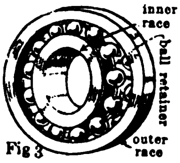


Fig 3

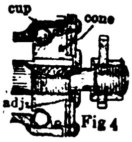


Fig 4

The cup and cone bearing is shown in fig. 4, and is used on many cars in the front wheels. This type of bearing is used extensively on bicycles. It is designed for radial loads but is capable of withstanding considerable thrust also. It is adjustable.

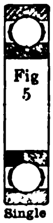


Fig 5

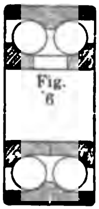


Fig. 6

Single double row annular ball bearings

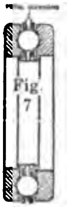


Fig. 7

ball thrust bearing

The annular ball bearing is a bearing with an inner and outer race, which is grooved and hardened. They are not adjustable. This type can be a "single row" of balls, per fig. 3 and 5, or "double row," fig. 6. The single row takes a radial load.

The races of the double row are so shaped, that it will withstand considerable thrust as well as a radial load. It is used where space would not permit the use of a separate radial and thrust bearing.

An example of where a bearing of this type is used is shown in fig. 4, page 32. Note the double row bearing is shown on the rear end of the worm taking the thrust (which is considerable), and also takes a radial load.

The ball thrust bearing is shown in fig. 7. This bearing can be used only where the load or stress is strictly a thrust or end to end load.

This type is often used in clutches and is extensively used on the propeller shaft driving the propellers of motor boats.

The two parts the balls touch are called races. The one or two balls at the lower side support the entire weight and must be strong enough to hold up without being crushed. In automobiles, the **balls** are large and run in size up to 1 in. di. hardened and polished.

Sometimes balls wear flat or crack; if so a click will be heard and must be replaced with perfect balls at once.

---

*See page 681 "adjusting front axle bearings" and page 669, "removing rear axle shafts."
†From Automobile Digest.

INSTRUCTION No. 5.

*CLUTCHES: Cone Disk and Plate Clutch. Universal Joints.

Purpose of the Clutch.

The word "clutch" as used in connection with automobiles, indicates a device attached to cars having change speed gears of the sliding type, **which permits the engine to be connected with, or disconnected from, the transmission,** so that the car may or may not move while the engine is running.

The clutch is connected and disconnected from fly wheel of engine by a foot lever.

When disconnected from flywheel of engine then there is no connection between the engine and rear axle.

When clutch is connected with flywheel of engine then the power of engine is connected with rear axle—**if** the gears of transmission are not in "**neutral**" position.

If gears are in neutral position then the power of engine would end at the end of the secondary shaft of transmission (see page 38).

While other types of transmissions require clutches, they are of special kinds, and will not be referred to in this lesson. (The Ford, for instance, uses a different principle.)

Because a steam engine has behind it the pressure of the boiler, it can be called on to supply much more than its regular horse power for short intervals.

A gasoline engine has no reserve power to call on, and cannot deliver more than a fixed horse power.

When the gasoline engine is required to start the car, it must overcome the inertia of the car. This might be greater than the power of the engine could accomplish, and the engine might be stopped instead of the car being started.

If the clutch made an immediate connection between the engine and the drive, the power of the engine would have to instantly overcome the inertia of the standing car.

The power of the engine coming from the revolving of the fly wheel, and the explosion that might be occurring in one of the cylinders, it would probably be stopped instead of the car being started.

If, however, the clutch is made so that the engine takes hold **gradually,** the inertia of the car will be overcome, and it will move faster and faster as the clutch permits the engine to apply its power more and more.

This is done by making the clutch in such a way that when it is applied, it **slips,** instead of instantly making a connection between the engine and the drive.

When the clutch is "**let in,**" it connects the crank shaft of engine through the fly wheel with the transmission through the clutch shaft, and if the gears are in the "neutral" (gears out of mesh) position, the counter or secondary shaft in the gear case of transmission will revolve without moving the car. See illustration page 50.

Clutches have two chief parts; one part (usually the flywheel, see chart 19, fig. 1), is attached to the crank shaft of the engine, the other part (cone or disk or plate) is attached to the clutch or main shaft of the transmission (see page 48, fig. 1). (134.)

When the two parts are separated, that is to say "clutch thrown out" by the clutch pedal, they are independent of each other and the engine can run without moving the car.

---

*See Dyke's working model of the clutch and gear box. For repairing clutches, see index. For make of clutch on different cars, see "Specifications of Leading Cars"—page 543.

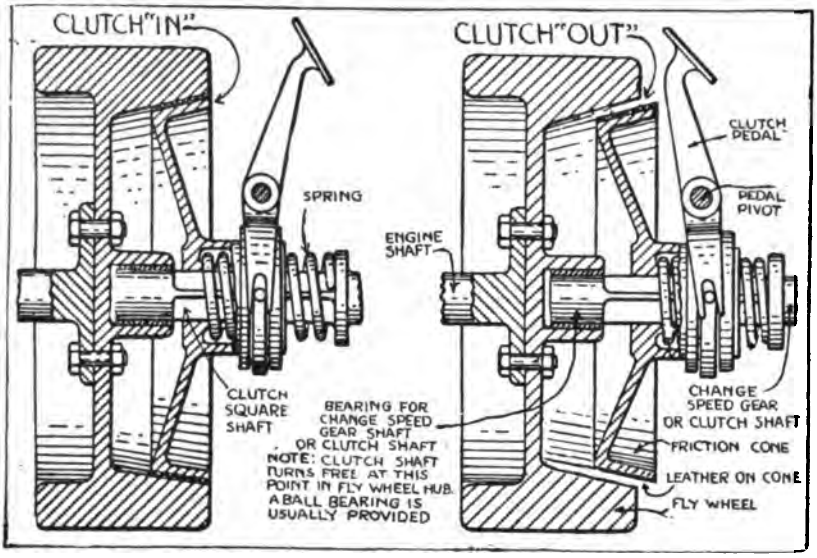

CLUTCH "IN"
CLUTCH "OUT"
SPRING
ENGINE SHAFT
CLUTCH PEDAL
PEDAL PIVOT
CLUTCH SQUARE SHAFT
BEARING FOR CHANGE SPEED GEAR SHAFT OR CLUTCH SHAFT
NOTE: CLUTCH SHAFT TURNS FREE AT THIS POINT IN FLY WHEEL HUB. A BALL BEARING IS USUALLY PROVIDED
CHANGE SPEED GEAR OR CLUTCH SHAFT
FRICTION CONE
LEATHER ON CONE
FLY WHEEL

Fig. 1—**Illustr** **how the cone t** **of clutch is fit** **into the fly wh**

Illustration sho same in section if cut in half. T cone is perfect circular, but co shaped and fit with leather wh grips the inner s face of the f wheel rim wh clutch is "in," which it always unless thrown "out" by th clutch foot pedal.

Note in illustra tion position of co when clutch "in" and "out." Also note clut shaft runs **free** in hub of fly wheel, usually on a ball bearing as per (CE), page 50.

By pressing clutch pedal the **pivot** causes lower part of pedal to throw clutch **out.** A all other times clutch is held **in** by tension of clutch spring.

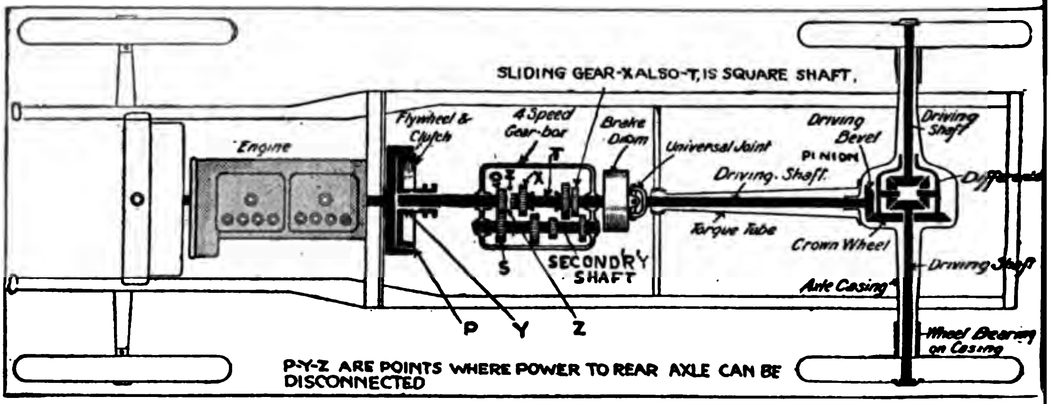


Fig. 2—Illustration explains how the **power is transmitted from engine to clutch, thence to secondary or counter shaft. Note** the **drive** parts are clutch, clutch shaft, drive gear (O), secondary shaft drive **gear** (S) and gear on secondary shaft. The **driven** gears are the sliding gears on the square shaft (T). **Note** power to rear axle is disconnected at points (P) when clutch is "out;" at (Y) as explained above, when clutch shaft turns free in hub of fly wheel and at (Z) when the **drive** and **driven** gears are in "neutral" or not in mesh.

Clutch action: Note the power from engine is transmitted to the clutch shaft **only through the clutch** when **in** the rim of the fly wheel (if disk or plate type, then by **the** disks or plates as explained under that type of clutch).

Observe that there is no shaft connection at (Y), but clutch **shaft** runs **free** at **all times** in hub of fly wheel. The cone part of clutch is connected with the clutch **shaft so that** when cone turns, clutch **shaft must also** turn. But observe that the cone **slides** on **the** square part of clutch shaft so that it can be pushed **out** by pedal or **in** by the spring.

When friction part of cone is out of fly wheel—**power ends at the fly wheel.**

When clutch is **in,** then **power ends at the end of the secondary or countershaft—if gears** are in "**neutral.**"

Turn to page 48 and study the meaning of "neutral" and see in **figs. 1, 2 and 3 how the rear axle is made to revolve.**

CHART NO. 19—Explaining the Purpose of a Clutch and how the engine can run yet not drive the **car.** Explanation of "clutch out" and "clutch in."

When the two parts are connected, that is, when the clutch is "let in" by releasing the clutch pedal, the part on the transmission shaft is forced into a frictional contact with the part on the crank shaft or flywheel by means of a powerful spring and held there. The two parts being thus connected forces the transmission to revolve with the engine and so drive the car, if gears are not in "neutral" as has been explained.

The part on the crank shaft does not grip the part on the clutch or transmission shaft immediately, unless they are moving at the same speed.

If they are moving at different speeds, which is usually the case, or when the part on the transmission is stationary, the two parts slip. This slipping continues until the two parts revolve at the same speed, when they bind together firmly. When "thrown out" they must separate instantly.

A disk or any other type of clutch used with the gear type of transmission is placed in the same relative position; **back of fly wheel,** between the fly wheel and gear case. Although the construction may vary, the reader will note that the **clutch principle is necessary on all cars.**

Clutch pedals—The **left** foot pedal on all cars of standard design, is the **clutch** pedal and on the **right** the foot **brake** pedal. See "operating a car."

Types of Clutches.

There are four types of clutches in general use; the cone, disk, plate, and †**expanding** type.

The disk clutch (formerly called the multiple disk) is a clutch with more than three disks and can be a **lubricated** disk clutch or **dry** disk clutch. A **plate clutch** is one wherein one plate is clamped between two others.

*The Cone Clutch—see chart 19.

This type of clutch is built into the fly wheel, and the fly wheel forms one of its parts. The rim of the fly wheel is broad, and the inside of the rim is made slightly funnel-shaped, forming the surface against which the other part of the clutch presses (fig. 1, chart 19).

The cone; the other part, called the "cone," is, as its name indicates cone-shaped, and fits into the funnel formed inside the fly wheel rim. The surface of the cone that bears against the fly wheel is often covered with **leather** to give good grip (one large manufacturer uses fabric running in oil).

The hub of the cone has a **square** hole, so that while it may slide on the **square** part of the clutch shaft which connects to the transmission sleeve (see 134, fig. 1, page 48), still the cone and shaft must revolve together. The forward end of the clutch shaft rests in a bearing formed in the hub of the wheel, so that it is supported, and yet may revolve independently of the fly wheel.

A heavy spring presses the cone against the seat formed in the rim of the fly wheel.

When the clutch pedal is pressed forward, the cone slides on the shaft away from the fly wheel, and separates from it, the spring being compressed (see fig. 1, page 38).

When the clutch pedal is released, the spring presses the cone against its seat, and if the crank shaft and sleeve are not making the same number of revolutions, the cone will slip. This friction makes the cone act as a brake on the crank shaft, slowing it, and at the same time the cone and sleeve are speeded up, so that the cone and fly wheel come to the same speed.

Clutch Operation—cone type as an example.

Fig. 2, page 38 (also page 50)—note the power from crank shaft of engine is transmitted to the clutch through friction connection with fly wheel, thence through gears, thence to drive shaft to bevel gear drive on the rear axle.

If engine is running, clutch could be "**in**" if gears are in "**neutral**" (not in mesh). If gears are in mesh with engine running then rear axle would revolve—unless clutch was "**out.**"

*See repair subject for adjusting clutches.

†The expanding shoe clutch is very seldom used. As has been previously stated, a successful clutch must be fairly light at the rim, but with the expanding clutch, owing to its method of operation, this is almost impossible.

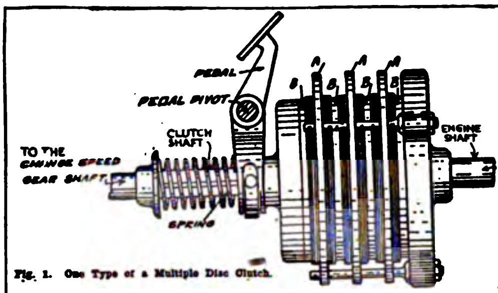


Fig. 1. One Type of a Multiple Disc Clutch.

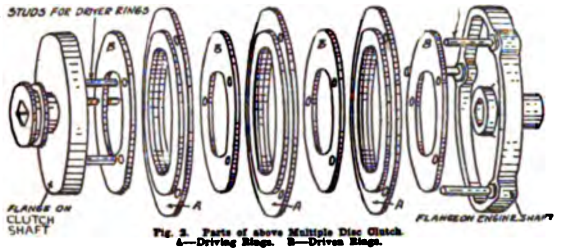


Fig. 2. Parts of above Multiple Disc Clutch. A—Driving Rings. B—Driven Rings.

Principle; Disk Clutch Lubricated Type.

Parts: Fig. 2 shows the parts of the clutch separated from each other. The disks (A) are attached to the flange on engine shaft, the smaller disks (B) are attached to the transmission shaft. The large disks (A) and small disks (B) are placed alternating.

The two flanges have pins extending from them, the disks having holes so that they may be slipped on the pins.

The small disks on their studs fit inside of the studs on the large flange, and the openings in the large disks permit the studs or pins on the small flange to pass through them. Thus the outer edges of the small disks come in contact with the inner edges of the large disks.

Assembled clutch: as will be seen from figure 1, which is the clutch assembled, the two flanges are connected only by the friction between the large and small disks, when the spring presses the parts together. The entire clutch is placed inside a casing, and runs in oil.

When the clutch pedal is pressed forward, the clutch is "thrown out," the oil then flows between the disks, and when the clutch is "in" and the spring presses the disks together, the oil is squeezed out from between them. While it is being squeezed out the clutch is slipping, and it begins to bind when the pressure has squeezed it out and the disks in consequence feel the effect of the friction. When the clutch is "thrown out," one set of disks may revolve independently of the other, for they are not connected in any way.

Hele-Shaw Disk Clutch.

In the Hele-Shaw disk clutch (fig. 4) a similar principle is adopted. The plates consist of a number of alternate bronze and steel disks much thinner. They are **corrugated** to increase the grip.

Half the plates are rotably connected by grooves with the driving member, and the alternate half with the driven member. When the clutch pedal is released, the clutch spring presses these disks together, and they all rotate as a solid mass. When the clutch pedal is depressed, the spring pressure is removed and the plates separated.

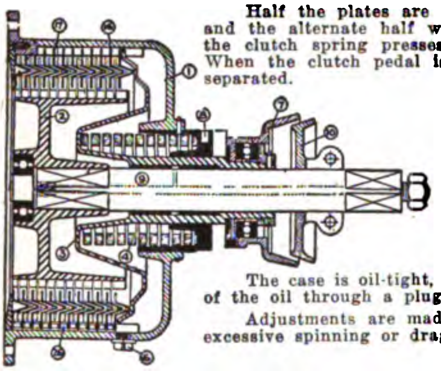


Fig. 4—The Hele-Shaw corrugated disk clutch-lubricated type.

Referring to the illustration (fig. 4) the outer oil-tight case (1), to which the driving bronze plates (16) are keyed, is bolted to the flywheel of the engine. The inner core (2) is keyed directly to the clutch shaft and to it are keyed driven steel plates (17).

The clutch is shown engaged as normally held by the spring (4) which actuates the ring (7) and the sliding presser (3). To facilitate quick disengagement, small springs (26) are fitted between the disks.

The case is oil-tight, provision being made for the replenishment of the oil through a plug (6) for the purpose.

Adjustments are made by means of an adjusting nut (8), and excessive spinning or dragging is prevented by a cone brake (10).

Cadillac—Dry Disk Clutch.

Fig. 5—The driving disks "A" are covered on both sides with a friction material, composed largely of asbestos, and are driven by six keys in the clutch ring "H" which is bolted to the engine fly wheel "G."

The driven disks "B" are not covered. These disks are carried on the clutch hub "E" and drive it through six keys on the hub. The clutch hub is keyed to the transmission shaft "F."

When the clutch is engaged by allowing the clutch pedal to come towards you, the spring "C" forces all of the disks together. The resulting friction between the disks "A" and "B" drives the transmission shaft "F" and the car, when the transmission control lever is in other than the neutral position.

There are no adjustments. The clutch pedal should be adjusted occasionally to compensate for wear on the facing of the clutch disks.

There is one point "D" on the clutch for lubrication.

There are 17 steel plates, having 9 driven disks and 8 driving disks. The coil spring is held under 300 lbs. compression.

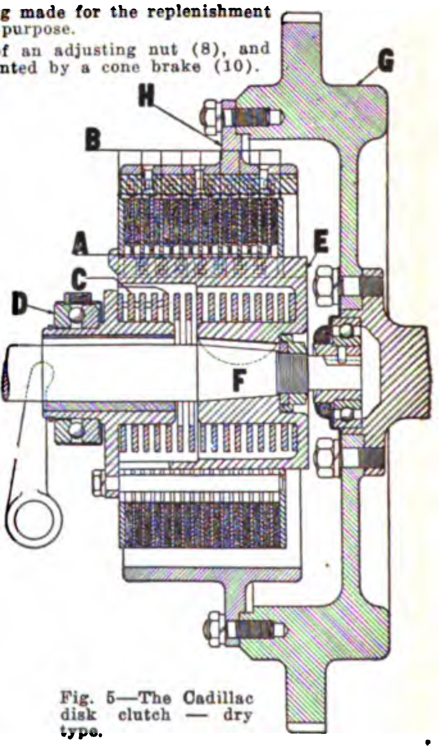


Fig. 5—The Cadillac disk clutch — dry type.

Therefore there are three methods of cutting off the power to rear axle; (1) stopping engine, (2) by throwing "out" clutch, (3) by having gears in "neutral."

The usual method to stop car and engine—is to "throw out" clutch, shift gears to "neutral" and apply foot brake. After **car** stops **then** turn off ignition switch and stop engine.

When starting engine the gears are placed in "**neutral**" position by the hand gear **shift** lever. (Note fig. 2, chart 19; also page 50. Gears are now in "neutral" position.) Engine can then be started without car moving.

To start car after engine is started; throw "out" clutch with foot pedal—shift gears in mesh (usually to lowest gear set), then gradually let clutch "in."

The term "clutch in" means, the clutch is allowed to press into the fly wheel by tension of spring.

The term "clutch out" means it is held out by foot clutch pedal. If car was running and you desired to coast, "throw out" clutch or disengage gears.

When stopping—throw "**clutch out**" by movement of foot pedal. (Usually left foot pedal.) Apply running brakes (usually right foot pedal.) Shift gears into "neutral" and then let "clutch in."

The clutch is used more than any other control on car—therefore **study the meaning of "clutch in," "clutch out," "gears in neutral."**

When the change speed gear is to be moved to a higher speed after starting or at any time when car is in motion or engine running, the clutch must first be "thrown out," for the gears could not be meshed with the countershaft revolving and the square shaft stationary; "throwing out" the clutch leaves the countershaft free to move as necessary to mesh the gears.

The cone clutch adjustments are simple. Examples are shown in the repair subject. See index. The "grabbing" feature is being done away with by insertion of springs, usually about 6 inserted under the leather. Slipping is overcome by clutch springs within the spider. See Buick clutch adjustment in repair subject.

*The Disk Clutch—see chart 20.

The disk clutch (formerly termed multiple disk), consists of a number of disks which are pressed together when the clutch is "**in,**" the friction between them causing one to drive the other. This type of clutch is very compact, and is frequently built inside of a metal housing cast to the engine frame.

To illustrate the principle of the disk clutch, place a silver dollar between two silver half-dollars, and squeeze them together between the thumb and forefinger of one hand. With the other hand, try to revolve the dollar not moving the halves. It requires only a slight squeeze to produce sufficient friction to make it impossible to move the dollar.

Multiple disk clutches are of two general types; those that operate in an oil bath and those that run dry; called **lubricated** and **dry** types

The lubricated disk clutch **runs in oil**; its disks are usually alternate steel and bronze or all steel disks, and the type that **runs dry** is usually of steel disks, one set of which is faced with a friction material of woven asbestos fabric.

The lubricated and dry types are described in chart 20.

The Plate Clutch.

The S. A. E. term the disk clutch (formerly called the multiple disk); a clutch with more than three disks. **The plate clutch** is where one plate is clamped between two others.

The single plate clutch is a popular type of clutch. It is a variation of the disk type, the latter comprising a large number of narrow disks, while the other usually consists of but three broad disks or plates, the ordinary type having two **driving** plates and one **driven** plate.

An example of a single plate clutch is described in detail in the following matter. In this type the clutch effect is created by **wedging** the plate. The type which will now be described is the Borg and Beck make (chart 20A, and page 43).

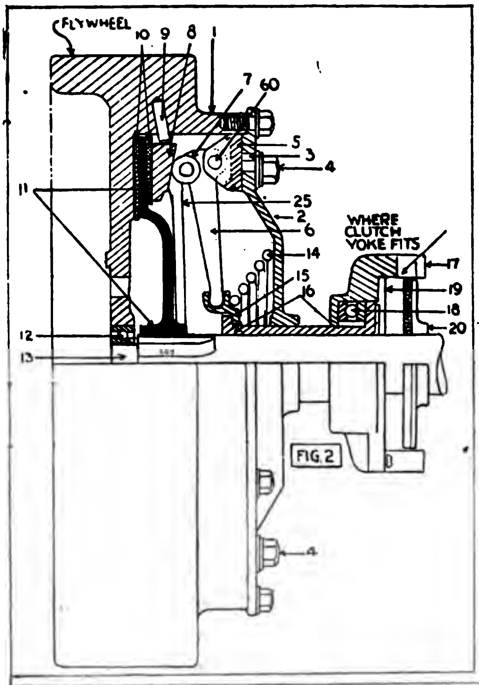


FIG. 2

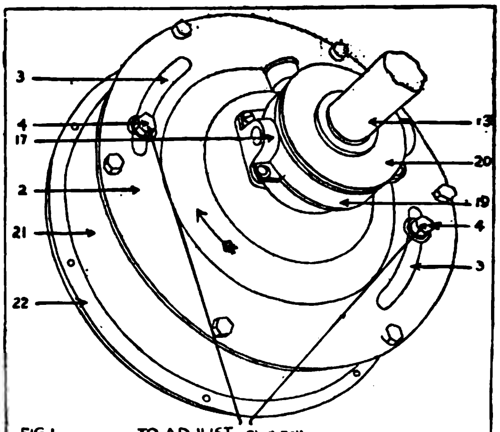


FIG 1

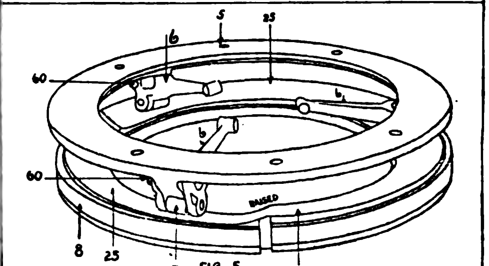


FIG. 5
ADJUSTMENT ACTION

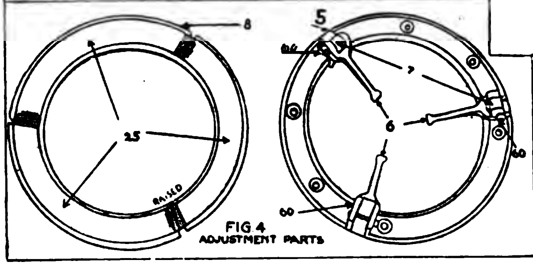


FIG 4
ADJUSTMENT PARTS

1—Clutch-Casing—cast with fly wheel.
2—Casing-Cover—carrying adjustment-ring.
3—Cover-Slot—for adjustment-bolt.
4—Adjustment-Bolt—for take-up action.
5—Adjustment-Ring—mounts thrust-levers.
6—Thrust-Lever (bell-crank)—mounts roller.
7—Thrust-Roller—acts against thrust-ring.
8—Thrust-Ring—acts against asbestos ring.
9—Driving-Pin—for thrust-ring.
10—Friction-Ring—asbestos.
11—Friction-Disk—driven.
12—Pilot Ball-Bearing—for end of shaft.
13—Clutch-Shaft—driven by disk.
14—Thrust-Spring—acts on "bell-crank" transmission.
15—Throw-out Collar—on throw-out sleeve.
16—Throw-out Sleeve—centered on shaft.
17—Throw-out Yoke—non-rotating.
18—Thrust Ball-Bearing—takes throw-out pull
19—Brake-Plate—rigid on throw-out yoke.
20—Brake-Collar—keyed on shaft.
21—Detachable-Casing—self-contained clutch.
22—Mounting-Flange—bolts against fly wheel.
23—Driving-Bolt—for thrust-ring (not shown).
24—Shaft, Brake and Universal Connection (not shown).
25—Adjustment-Incline—take-up seat for roller.
60—Bell-Crank Pivot—mounts thrust-lever.

Borg & Beck Single Plate Clutch.

Principle: This type of clutch runs dry. The action is best understood when it is kept in mind that among the revolving parts, only the **driven** group; disk 11, shaft 13 and brake collar 20, can stand still when fly wheel is running; and all other parts being "anchored" to fly wheel must always revolve and drive with the latter.

When clutch is "in:" The asbestos friction rings 10, though not positively attached to either the driving or the driven parts, will, in practice, "freeze" to the unpolished faces of the inner case of fly wheel and thrust ring 8; and thus always run bodily with the fly wheel.

When clutch is "out:" The foot lever is applied which telescopes the coil spring (14) back, by action of the throw out sleeve (16) which causes the roller (7) to withdraw a sufficient distance from face of thrust ring (8), to permit the latter, with its companion friction ring (10), to "back-away" bodily, from friction disk (11), thus releasing the disk from the friction-grip, and permitting it and other driven parts to come to a stop, while fly wheel and parts anchored to it revolve.

CHART NO. 20-A—Principle and Construction of a Modern Single Plate Clutch—dry type. (T Borg and Beck Co., Moline, Ill.)—see also pages 668 and 842.

†Adjusting the Single Plate Dry Clutch—per chart 20-A.

Take up action: The roller seat face of the thrust ring (8), is formed on three, equal succeeding, takeup "inclines" (25); the ring being ¼ inch **thicker**, at the high end of each "incline" (25), than at the beginning, or low end. The three thrust-levers (6), are mounted upon, and equally spaced by, the adjustment ring (5); and this ring is adjustably mounted against the inner face of the cover (2), by means of the adjustment—bolts (4) of which there are two, through slots (3) in the cover.

When the bolts (4), are "slacked," and shifted in their cover-slots (3), they control and shift with them the ring (5), the latter carrying with it the levers and rollers (6 and 7)—thus shifting all the rollers to new seats against the non-shifting thrust-ring; and, these seats being further up the ring "inclines" (25), where the inclines are thicker in cross section, the ring is necessarily thrust so much further toward the other friction parts, to compensate for any friction wear, and to maintain, at all times, a perfect friction grip.

Therefore to adjust clutch, the clutch is held entirely out.

With the clutch thus held "out," it is only necessary to "slack" the adjustment-bolts (4), tap either of them "**clockwise,**" in the slot (3) on cover, **a quarter or half inch,** or any other distance required, thus shifting the ring (5), carrying the levers and rollers to new seats, upon thicker sections of the thrust-ring; and thus compensating for the friction-wear which made the adjustment necessary.

If too much oil gets into clutch and causes slipping: In this case it will be necessary to unscrew the bolts (4) about three turns, have some one hold out clutch and let oil drain out. It is also desirable to squirt gasoline into interior of clutch to wash out the oil. If slipping continues the trouble is due to oil working into clutch housing and must be separated from main oil supply of oil pan of engine.

Removing clutch: First remove transmission. Mark clutch cover that bolts to flywheel with punch and corresponding mark on flywheel, in order that it is put back in same position. Cover plate must not be turned.

Replacing clutch: There are two asbestos fabric rings; one lays against face of fly wheel (10), next to this comes the driven plate (11), then other friction washer (10). The cast thrust ring (8) comes next, but before installing, make sure the driving pins (9) are in place in the inside of the fly wheel rim. Drop thrust ring (8) in position so that the three slots fit over pins (9). The adjustment ring (5) with its parts assembled to it should now be installed. The adjusting ring (5) fastened to the cover plate by means of two cap screws and cover plate bolts to fly wheel.

Clutch brake is provided which comes into action when the clutch pedal is pushed all the way down. Purpose is to stop spinning of transmission gears when clutch is disengaged. The throw out collar (15) presses against the brake collar (20). The clutch brake is mounted on the transmission shaft and is faced with asbestos fabric.

If worn, trouble will be experienced when shifting gears into first speed when car is standing. Clutch will appear to drag and will continue to drive transmission gears when fully disengaged, so it will be difficult to mesh gears.

To remedy, remove oil pan, have some one hold out clutch, while throw-out clutch and collar are examined; to see if collar (20) actually touches brake or not. If it does not, the transmission should be removed and if brake friction facing is in good condition no need of installing a new one. See that the throw-out is not coming in contact with brake flange and should be adjusted so that these two points form a contact.

Note—always remember to drive with **foot off the clutch pedal.** Make sure clutch pedal does **not strike or press against toe board.**

*Universal Joints.

A universal joint is a flexible connection between two shafts, which permits one to drive the other, although they may not be in line. Refer to figs. 2, 3 and 5 and study the principle. Universal joints are usually placed forward and rear of the drive shaft (see page 50).

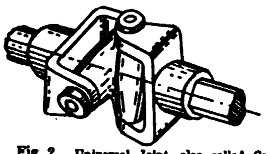


Fig. 2. Universal Joint, also called Cardan Joint—note straight line.

Universal joints are necessary on automobiles with shaft drive, for while one end of the driving shaft is attached to the transmission shaft, which is on the frame, the other end is connected to the axle, and constantly moving up and down as the wheels follow the roughness of the road.

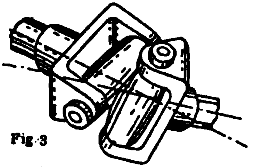


Fig 3

Another view of Universal Joint—note it is now out of line.

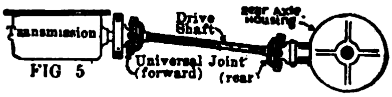


FIG 5

If no universal joints were used, the shaft would jam in its bearings from the up and down movement of one end of it.

---

*Universal joints are also called cardan joints. See pages 680, 681 for construction of "universal joints." †See pages 668 and 842 for other adjustments on Borg and Beck clutch. See foot note page 662, why gears of transmission are sometimes difficult to shift.

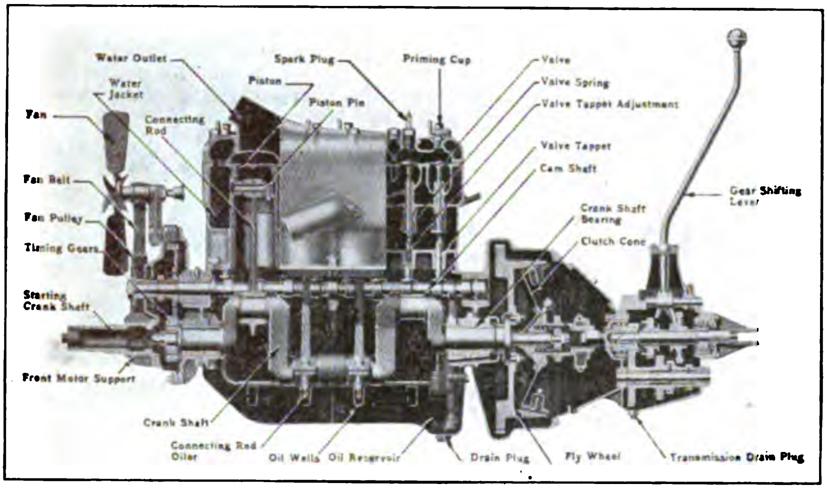


Fig. 1: A modern unit power plant, the Dort.

The engine of this unit **power** plant has "**L**" **head cylinders cast** in **block**; valves on **side**, poppet **type**; **detachable cylinder** head (see **index**, "cylinder **head**, replacing of.")

Transmission: selective **type**, 3 speeds ahead and reverse. **Clutch**; cone type. **Gear shift lever**; ball and socket **type**.

Left, foot **clutch pedal** and **right**, foot **brake pedal**.

Power is **transmitted** to **rear** axle from end of transmission shaft (upper one).

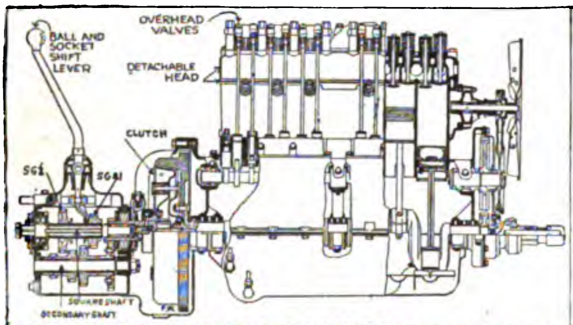


FIG.2 UNIT POWER PLANT WITH OVERHEAD VALVES & DETATCHABLE CYL.HEAD

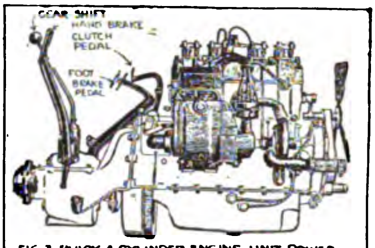


FIG.3 BUICK 4 CYLINDER ENGINE UNIT POWER PLANT WITH OVERHEAD VALVES.

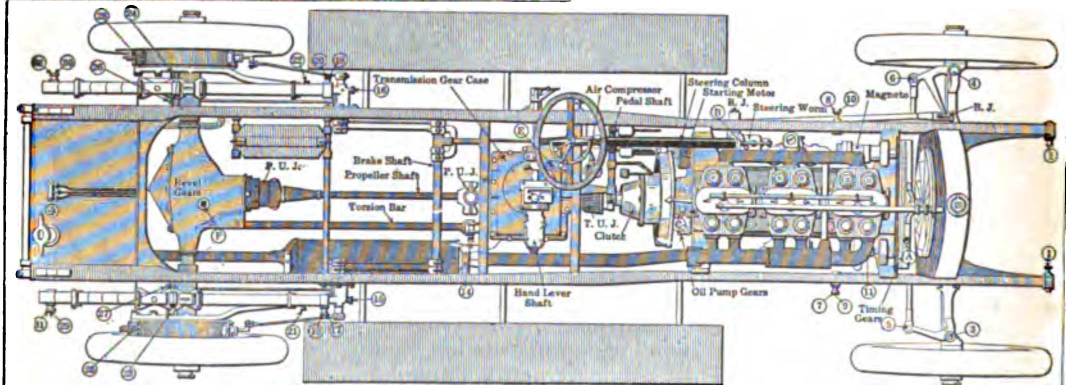


FIG 4 Locomobile Chassis. The "38" Type R-7. The "48" Type M-7

Fig. 2: **Unit power plant with valves in the head and a detachable cylinder head. (The Oakland six). The head is detached with valves. This differs from fig. 1, in that the head is detachable, but the valves are not in the head in fig. 1.**

Fig. 3: **The Buick 4 cylinder engine unit power plant with valves in the head and detachable cylinder head. Note the Delco "single unit" electric system; starting motor, generator and ignition in one unit.**

Fig. 4: The Locomobile **engine and clutch are in one unit, but the transmission is separate.** Note universal joint (T. U. J.) between the clutch and transmission—see also page 499.

CHART NO. 21—**Unit Power Plant**; engine, clutch and transmission mounted in one **unit. Separate Power Plant.** Engine and clutch form one unit. Transmission separate.

(**Chart 22 on page 50**).

INSTRUCTION No. 6.

TRANSMISSION: Principle of Operation, Location, Different Types.

Principle of a Transmission.

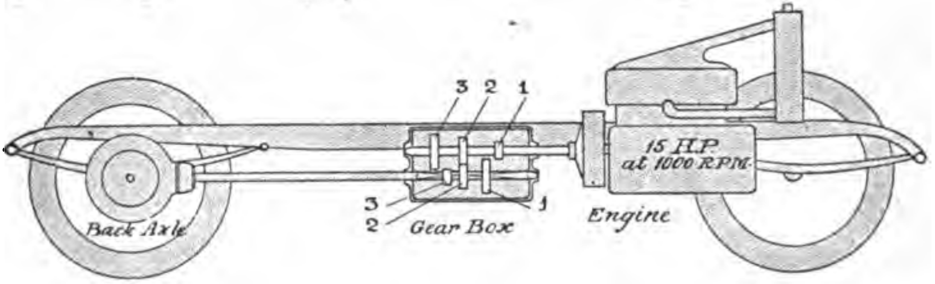
When a bicyclist wants to race on a level track, he gears up his wheel with a larger sprocket so that one revolution of the crank takes him farther. Yet if he takes this wheel with this large sprocket on the pedal shaft, out on the road where there are hills, he must get off and walk or exert an extra lot of power. This clearly shows that if a bicyclist wants to speed while on the level and yet take all hills, he must change the drive sprocket.

The same principle applies to the automobile—therefore the automobile is provided with not only two changes of gears (instead of sprockets), but it has three and sometimes four changes of gears, which gears are contained in a gear box usually placed back of the clutch. (See page 38).

The principle upon which all change-speed gears work is the fact that when two cog-wheels or spur gears are meshed together the larger wheel turns more slowly than the smaller wheel.

As an example, a cog-wheel with 10 cogs, in mesh with a second wheel having 20, would revolve twice as fast as the latter, the explanation being, that when the 10 cogs of the smaller wheel have moved round once they will have engaged with only 10 cogs of the larger wheel, and therefore will have turned the larger wheel through only half a revolution, that is, that it will be necessary for the smaller wheel to revolve twice in order that the larger one may revolve once.

*With this piece of elementary information, we will observe that in the gear-box (see below) there are two shafts—the upper one coming from the engine through the clutch, and the lower one continuing to the back axle.



Each shaft is fitted with three different sized cog-wheels numbered in the illustration 1, 2 and 3; those on the upper shaft are fixed to the shaft itself, but those on the lower shaft are able to slide on a keyway, to right and left along the shaft. The shaft is not round like the upper one, but is **squared,** so that although the sleeve of cog-wheels can slide backward and forward, they cannot revolve independently of the lower shaft.

In order now to vary the speed of the car, it is only necessary to slide the cog-wheels (gears) along the lower shaft until the correct two gears come into mesh to form the gearing required.

The illustration, for instance, shows intermediate speed gear in mesh, but were we to **move the gears to the right** so that wheels 1 and 1 come into mesh, we should put the car on its **first speed,** that is its **lowest speed,** so that with the engine running normally the car would be moving very **slowly,** the driving gear being much smaller than the driven gear.

When, however the sleeve is moved to the left so that gears 3 and 3 mesh, the effect is reversed. Now we have the **driving** gear much larger than that **driven,** and the result will be that when the engine runs normally the car will be traveling at a very high speed.

*This illustration is intended to simplify the explanation. In actual practice the arrangement is slightly different (see page 46); the sliding gears are usually above, clutch shaft and transmission shaft are not continuous as shown and drive shaft connects with transmission main shaft instead of counter shaft.

The number of revolutions made by the engine to one of the wheels is different with different manufacturers, but as a general thing, when on the low speed the engine makes from twelve to eighteen revolutions to one of the road wheels, and on high speed from one and a half to four revolutions to one of the road wheels.

The sides of the teeth of the gears are usually made like the point of a chisel, so that when two gears are brought together they will mesh easily. If the sides of the teeth were flat, as in ordinary gears, it would be difficult to slide them into mesh. (Mesh means the teeth of two gear wheels engaged.)

When sliding the gears from one speed to another, the main clutch in fly wheel must always be thrown out.

With the main clutch in the fly wheel thrown out, the sliding gear on the square shaft is free to move and its speed may easily be changed. If the change were to be made with the engine driving the upper shaft, changing the speed of the gear would require the speed of the engine to be changed; or changing the speed of the gear on the square shaft would require the speed of the car to be changed.

Neutral—means that the gears are not meshed or in engagement at all. Therefore power to rear axle is cut off, yet engine is free to run although the clutch is in engagement with fly wheel.

When running it is always necessary in shifting gears, to **first throw clutch out** of engagement with fly wheel, then bring gears to **neutral** position and then shift from a **lower to higher gear,** unless car is gradually slowing down, then a shift to lower gear would be in order. But never shift to a lower gear when running at fast speed, as there is a liability of stripping the teeth from the gears, or if the teeth were strong enough to stand it, the car would be badly jolted. Therefore, **always throw out the clutch in the fly wheel before changing gears and let car slow down if shifting to a lower gear.** It is seldom, however, a shift to lower gear is made unless car slows down, and it is unnecessary to slow car down.

****To reverse motion of car** the reverse gear must never be used until the car is at a **dead stand still.**

The location of the transmission may be either in front; adjoining the clutch, or on the rear axle housing; see chart 24, figs. 2 and 7. The modern method is the "**unit power plant,**" where the transmission and clutch are connected to the engine as one unit. See pages 44 and 50.

Types of Transmissions.

There are three types: the sliding gear, planetary and friction disk type.

The **planetary** type is used on the Ford (see Ford instruction). The **friction disk type** is used on light cars to a certain extent as cycle cars, etc., see fig. 4, chart 24 for principle.

There are two types of sliding gear systems; the old style **progressive** type (fig. 2) and the modern **selective** gear type, pages 48 and 50.

The progressive type was discarded because it was necessary to pass one gear through another which made a clashing noise and difficult at times to operate.

With the selective type it is not necessary for the sliding gear to pass through another gear. It is easier and quicker to operate and considerably less noisy. It is with this type we shall deal.

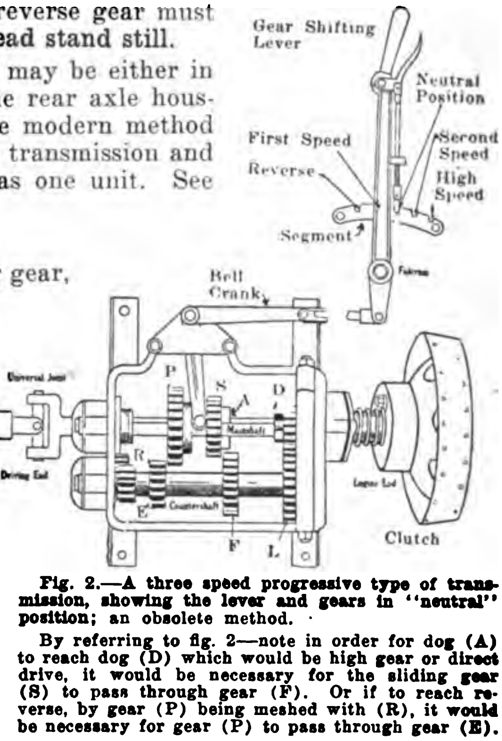


Fig. 2.—A three speed progressive type of transmission, showing the lever and gears in "neutral" position; an obsolete method.

By referring to fig. 2—note in order for dog (A) to reach dog (D) which would be high gear or direct drive, it would be necessary for the sliding gear (S) to pass through gear (F). Or if to reach reverse, by gear (P) being meshed with (R), it would be necessary for gear (P) to pass through gear (E).

---

*Transmissions are also called change speed gears or gear boxes. **See pages 48 and 50.

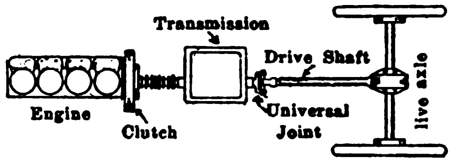


Fig. 2. **Shaft drive type of transmission.** Transmission mounted on frame directly back of clutch and is of the gear type. This type used to great extent on pleasure cars. Transmission of the gear type.

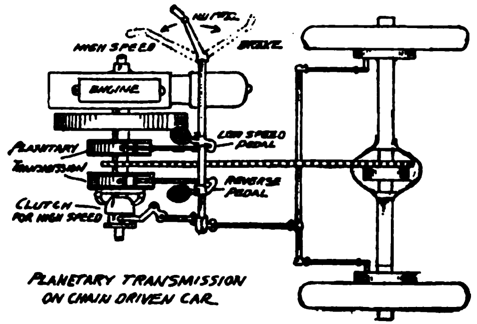


Fig. 5. **Single chain drive type of planetary transmission.** The transmission is mounted to the side of the engine. The type of transmission is the planetary type. This system is now seldom used.

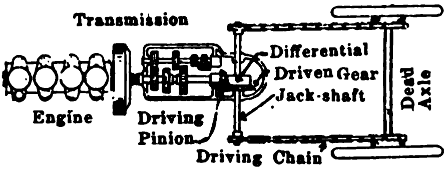


Fig. 3. **Double chain drive type of transmission.** Transmission is mounted on frame and is connected by bevel gears to a jack shaft. This type used to a great extent on trucks. Transmission of the gear type.

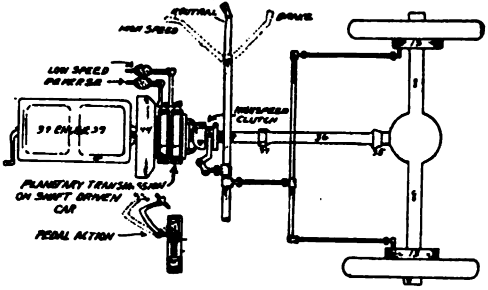


Fig. 6. **Shaft drive type of planetary transmission as used on the Ford.** (See Ford Instruction.)

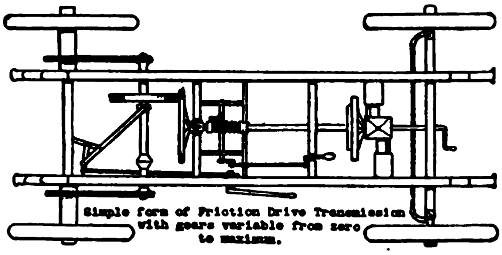

Simple form of Friction Drive Transmission with gears variable from zero to maximum.

Fig. 4. The friction disc type of drive of transmission used on the Carter Car. It is extensively used on Cycle Cars.

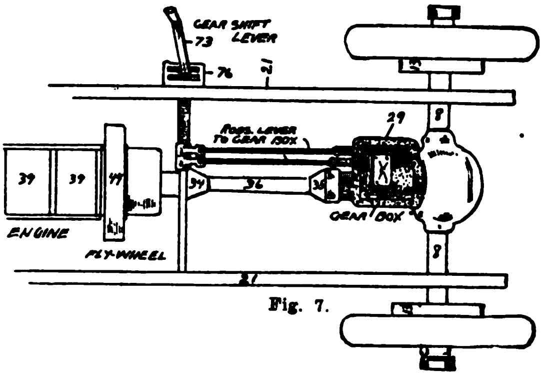


Fig. 7.

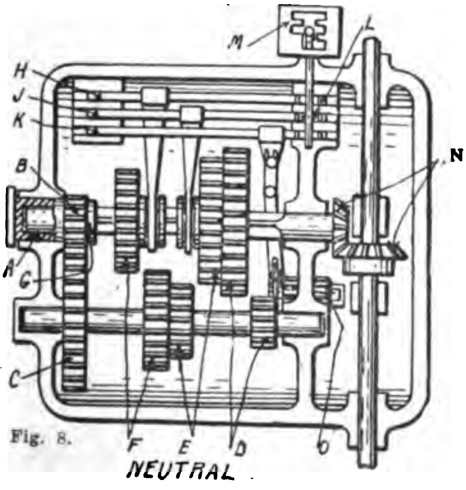


Fig. 8.

Fig. 7—The method of placing the gear type transmission on the rear axle. See also page 204.

Fig. 8—Four speed selective type of transmission for a double chain driven drive car.

The only difference between this type and the one in (Chart 23), is that a jackshaft with bevel gears (N), is employed. (See fig. 3 above.)

When there are four changes of speeds, note that there are three shifting forks (H, J and K). The drive gear (B) is attached to the sleeve (A), which connects with engine drive shaft through the clutch.

A—Sleeve driven by engine.
B—Gear on sleeve.
C—Gear on countershaft.
D—Low speed gears.
E—Second speed gears.
F—Third speed gears.
G—Clutch for high speed.
H—Rod and arm for third and high speed.
J—Rod and arm for low and second speed.
K—Rod and arm for reverse.
L—Finger in groove.
M—Guide plate for selective lever, also called a "gate."
N—Bevel gears to jack shaft.
O—Idler for reverse.

CHART NO. 24—Location of Gear Box (Transmission) Four Speed Selective Type Transmission.

(Chart 22 is on page 50).

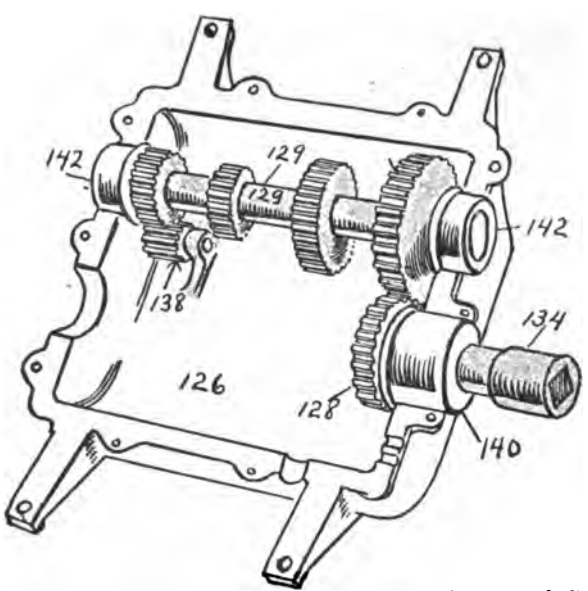


Fig. 1: **The lower half of transmission with countershaft (129) and its gears which are permanently attached thereto. Idler gear (138), clutch or main drive gear (128), clutch shaft (134) are also illustrated.**

Note:—When clutch and transmission are in one unit, the shaft (134) has no square hole—see page 50. Gear (128). countershaft drive gear and its shaft (129) always turn together.

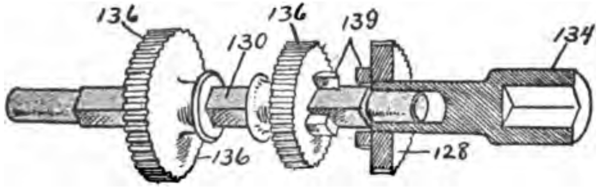


Fig. 3: **Transmission square drive shaft (130) and sliding gears (136). Note forward end of square shaft (130) runs free into end of clutch gear and shaft. If dogs (139) are brought together by sliding gear (SG-1, fig. 2) forward, then square shaft (130) would revolve with clutch shaft (134)—this would be "direct" or "high" gear drive.**

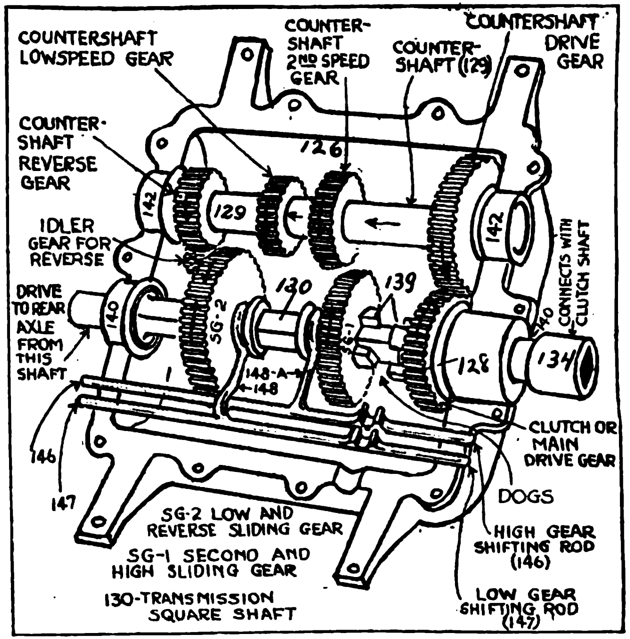

COUNTERSHAFT LOWSPEED GEAR
COUNTER-SHAFT 2ND SPEED GEAR
COUNTER-SHAFT (129)
COUNTERSHAFT DRIVE GEAR
COUNTER-SHAFT REVERSE GEAR
IDLER GEAR FOR REVERSE
DRIVE TO REAR AXLE FROM THIS SHAFT
126
142
129
142
130
139
SG-2
SG-1
140
CONNECTS WITH CLUTCH SHAFT
128
134
148-A
148
1
146
147
CLUTCH OR MAIN DRIVE GEAR
DOGS
SG-2 LOW AND REVERSE SLIDING GEAR
SG-1 SECOND AND HIGH SLIDING GEAR
130-TRANSMISSION SQUARE SHAFT
HIGH GEAR SHIFTING ROD (146)
LOW GEAR SHIFTING ROD (147)

Fig. 2: How the change of gears are obtained. Note in fig. 3 the square shaft (130) is independent of the secondary shaft. Also note in fig. 2 that gear (128) and drive gear on countershaft and the countershaft itself (129), always turn together, therefore, power from engine would end at shaft 129 providing sliding gears (SG-1 & SG-2) were in position shown, which is "neutral" position.

Neutral, means the sliding gear is not in mesh with the gear that drives it, therefore with present position as illustrated in fig. 2 we could not drive the rear axle, even though the engine was running and clutch "in."

First or low speed would be obtained by shifting gear (SG-2) in mesh with countershaft low speed gear. **Second speed**, would be obtained by shifting sliding gear (SG-1) in mesh with countershaft second speed gear. **Third or high speed**, would be obtained by shifting (SG-1) forward so dogs (139) would grip, then the drive would be **direct** to rear axle, but countershaft and its gears would also turn, but not being in mesh with the driven gears it would make no difference. **Reverse** would be obtained by shifting (SG-2) back until it meshes with idler gear which would reverse the direction of drive shaft (130).

Remember—gears cannot be shifted until lever is brought to "**neutral**" position. Also see pages 50 and 51, and foot note page 662.

CHART NO. 28—Simplified Illustrations Explaining the Principle of Operation and the Change of Gears in a Selective Type of Transmission with Three Speeds Forward and Reverse. Note—in modern transmissions the transmission shaft (130) sets horizontally over the countershaft as per page 44. Another change made in some transmissions, is the elimination of dogs (139); the gear (128) fits internally into the main drive gear (SG-1). **See page 50.**

The Selective Gear Type Transmission.

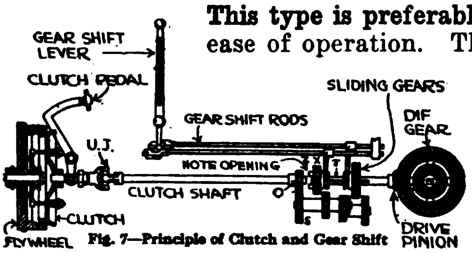


Fig. 7—Principle of Clutch and Gear Shift

This type is preferable, due to absence of noise of gears and ease of operation. The gear change ratio or gear desired, is "selected" by movement of the gear shift lever and the shift can be made without one gear passing through another.

Relation of the gears to the clutch is shown in fig. 7, and fig. 2, page 38. Principle of the selective type transmission is shown on pages 48 and 50.

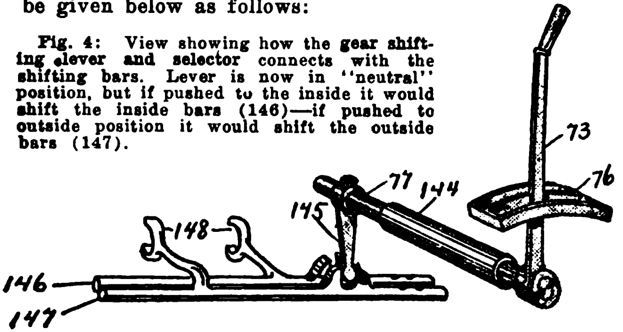
Referring to fig. 7, note power is transmitted from fly wheel to clutch, thence clutch shaft to gear O and S, through sliding gear for 1st or 2nd speed. For high speed, small dog clutches on gear X mesh with dogs on gear O, which makes the drive direct to rear axle.

Operation of the Gear Shift Lever.

There are two types of gear shift levers; the "gate" principle as per figs. 4 and 2 below, and the "**ball and socket**" type shown in fig. 1. The latter being used more than any other type.

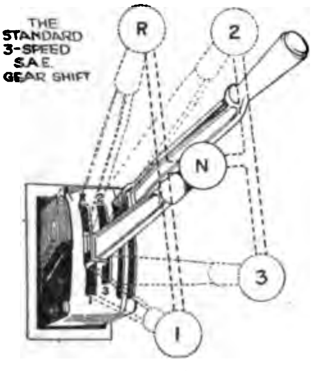
A simplified explanation of how the parts operate is shown in fig. 4. If the reader will first refer to page 48 he will understand just how the shift lever operates in relation to the shift bars (146 and 147) and shifting gears (SG-1 and SG-2). Further detail will be given below as follows:

Fig. 4: View showing how the **gear shifting lever and selector** connects with the shifting bars. Lever is now in "neutral" position, but if pushed to the inside it would shift the inside bars (146)—if pushed to outside position it would shift the outside bars (147).



By moving lever (73) in, to the left, the arm (145) engages with gear shift bar (146). Then by moving it (73) **forward** or **backwards,** the sliding gear (SG-1) is moved to "**second**" or "**high**" speed engagement.

By moving (73) out, to the right, this action causes arm (145) to engage shifting bar (147) which shifts sliding gear (SG-2) **forward; forward** movement of lever (73) throws sliding gear (SG-2) in mesh with "**reverse**" speed gear on counter shaft, while a **backward** movement throws (SG-2) in mesh with "**low**" speed gear.



†**Fig. 2.—Gate type** of gear shift lever is now in "neutral" position (N). The hand or emergency brake lever to the right is "set" until ready to start car. (1) is "low speed" position; (2), "second or intermediate;" (3) is "high" speed; (R) reverse. Movements vary on different cars. (See index "gear shifts of leading cars.")

When lever (73) is erect and in between the two slots as shown in illustration fig. 4, the slots which (145) work in are in line and all gears are out of mesh, or in "**neutral**" as it is called. For instance, the gears in fig. 2, page 48 are out of mesh, and slots on shifting bars are in line, therefore gears are in neutral.

Gate type: by studying the illustration fig. 2 on page 48 and figs. 4 and 2 on this page, the reader will readily see how the gears are shifted.

The lever (73), the gate or selector (76), and the other parts are numbered and named.

Note this lever moves **sidewise** as well as forward and backward (see figs. 4 and 2).

The ball and socket type of gear shift lever is identically the same principle except the movement of lever (73), fig. 1, is in a ball and socket instead of a gate. Note arm (145) serves the same purpose as arm (145), fig. 4, above. This type is the type in general use.

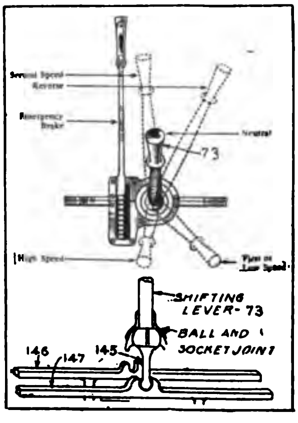


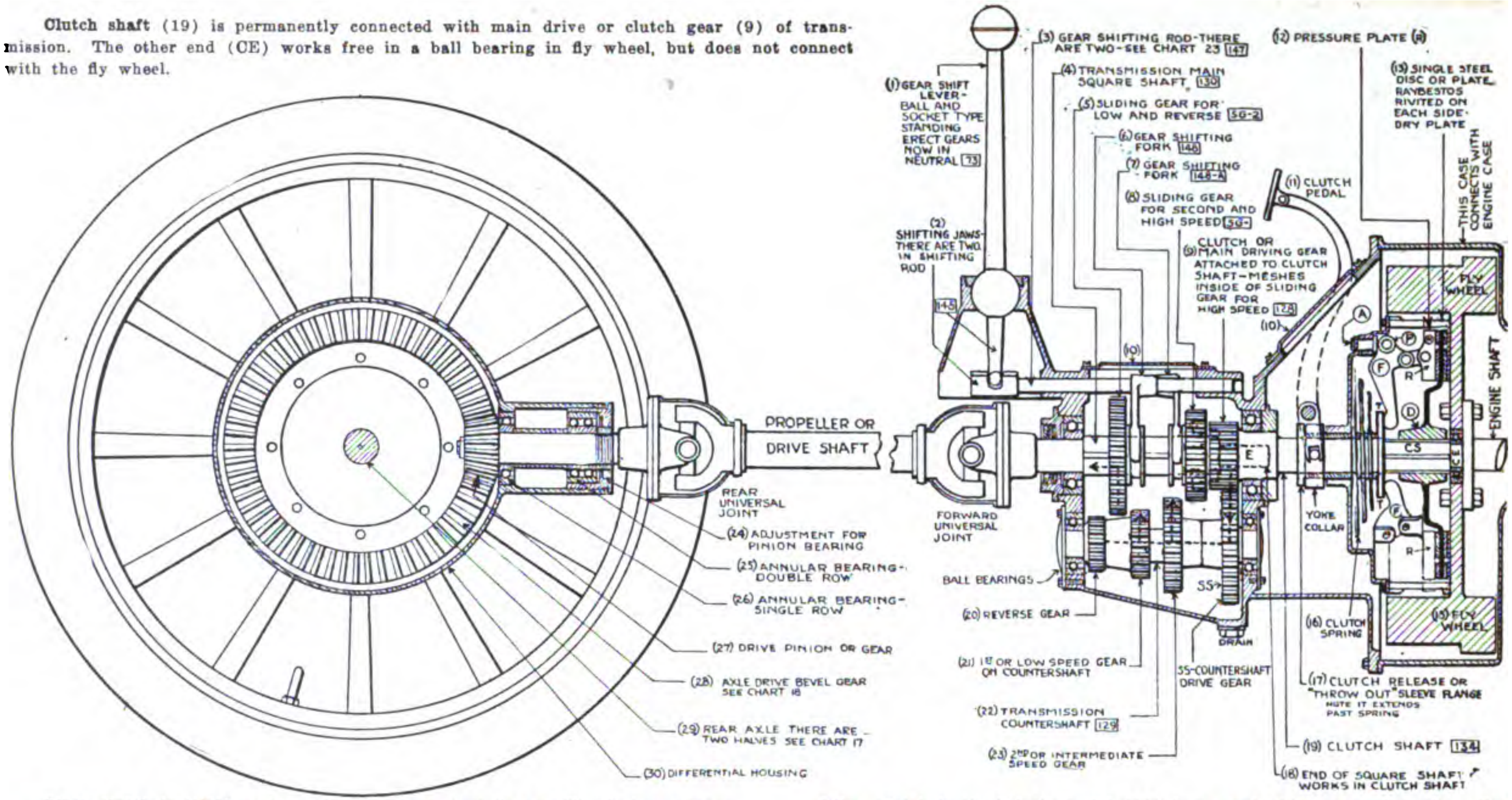
Fig. 1.—Ball and socket type of gear shift lever (73) is now standing upright in center of the socket and is in "neutral" position.

***Note the movement of gear shift lever in fig. 2. This is the type used on the Overland model 85.**

The movement of lever (73) in fig. 4 varies slightly from movement of lever in fig. 2 this page. For instance, if lever (73) in fig. 4, is shifted in to the left and back, we would have 3rd or high speed; if to the left forward, 2nd speed; if to the right side and backwards, 1st or low speed and if to the right side, forward, reverse speed. (See fig. 4 this page and fig. 2, page 48).

†This is the standard S. A. E. three speed gear shift. Illustration is that of the Overland, see pages 490, 497 and 358.

Clutch shaft (19) is permanently connected with main drive or clutch gear (9) of transmission. The other end (CE) works free in a ball bearing in fly wheel, but does not connect with the fly wheel.


(1) GEAR SHIFT LEVER-BALL AND SOCKET TYPE STANDING ERECT GEARS NOW IN NEUTRAL 73
(2) SHIFTING JAWS-THERE ARE TWO IN SHIFTING ROD
145
(3) GEAR SHIFTING ROD-THERE ARE TWO-SEE CHART 23 147
(4) TRANSMISSION MAIN SQUARE SHAFT 130
(5) SLIDING GEAR FOR LOW AND REVERSE 50-2
(6) GEAR SHIFTING FORK 146
(7) GEAR SHIFTING FORK 148-A
(8) SLIDING GEAR FOR SECOND AND HIGH SPEED 50-
(9) CLUTCH OR MAIN DRIVING GEAR ATTACHED TO CLUTCH SHAFT-MESHES INSIDE OF SLIDING GEAR FOR HIGH SPEED 128
(10)
(11) CLUTCH PEDAL
(12) PRESSURE PLATE (R)
(13) SINGLE STEEL DISC OR PLATE. RAYBESTOS RIVITED ON EACH SIDE. DRY PLATE
THIS CASE CONNECTS WITH ENGINE CASE
FLY WHEEL
ENGINE SHAFT
A
P
F
R
D
CS
CE
E
T
YOKE COLLAR
(15) FLY WHEEL
(16) CLUTCH SPRING
(17) CLUTCH RELEASE OR "THROW OUT" SLEEVE FLANGE NOTE IT EXTENDS PAST SPRING
(19) CLUTCH SHAFT 134
(18) END OF SQUARE SHAFT WORKS IN CLUTCH SHAFT
55
DRAIN
55-COUNTERSHAFT DRIVE GEAR
(23) 2ND OR INTERMEDIATE SPEED GEAR
(22) TRANSMISSION COUNTERSHAFT 129
(21) 1ST OR LOW SPEED GEAR ON COUNTERSHAFT
(20) REVERSE GEAR
BALL BEARINGS
FORWARD UNIVERSAL JOINT
PROPELLER OR DRIVE SHAFT
REAR UNIVERSAL JOINT
(24) ADJUSTMENT FOR PINION BEARING
(25) ANNULAR BEARING-DOUBLE ROW
(26) ANNULAR BEARING-SINGLE ROW
(27) DRIVE PINION OR GEAR
(28) AXLE DRIVE BEVEL GEAR SEE CHART 18
(29) REAR AXLE THERE ARE TWO HALVES SEE CHART 17
(30) DIFFERENTIAL HOUSING

When clutch is "in" spring (16) presses against flange (T) of sleeve, causing the three fingers working on pivots (F) to apply pressure through pressure plate (R) (which is a ring), this in turn applies pressure against the single plate. The **single plate (13) is fitted with Raybestos riveted on each side. This friction material clutches the fly wheel. Drive is then through driven plate (13) to plate hub (D), then square section of clutch shaft (CS) to main drive gear (9). Note (CS) part of clutch shaft is squared and clutch plate hub (D) slides thereon.**

When clutch is "out," the pedal (11) is pressed, this causes the yoke collar to press against flange (17) of the sleeve. This action causes flange (T) on other end of sleeve to relieve pressure against fingers (F). This releases pres**sure against the single plate (13).**

The adjustment of fingers (F) or pressure against plate is at (A). This type clutch runs without oil.

Note.—Figures in the square at end of wording compare with reference figures on transmission in chart 23.

HART NO. 22—Principle and Operation of a Single Plate Clutch (see page 42), Selective Type of Transmission and Method of Driving Rear Axle. A modern Unit Power Plant. The clutch may be of any one of three types; cone, disk or plate. The transmission is a three speed and reverse type.

23 is on page 48).

How the Various Speeds are Obtained By Shifting Gears.

NOTE—**The clutch is always engaged** or **in**—unless held out by clutch pedal. Therefore gears must be **out** of mesh or in **neutral** before starting engine.

When shifting gears, engine is supposed to be running, therefore always hold clutch **out** while moving the change or shift.

Never shift from high to low gear, unless car is slowed down to a very low speed.

Obtaining Various Speeds.

Before describing the operation of changing speeds, it is **most important to notice** in chart 22, that the main shaft of the transmission (4) is **not square continuously** right through the gear box. One end (E) works free into end of clutch shaft, so when gears are in "neutral" or not in mesh, there is no connection between clutch and transmission. A study of fig. 3, chart 23, will assist the reader in understanding this. Also note remarks under "clutch shaft" in chart 22.

"**Neutral**;" by observing the position of gears, it will be noticed that none of the gears are in mesh except the main clutch drive gear (9) (called clutch gear), connected with the clutch shaft and the gear (SS) on the countershaft. If we then follow the dotted lines and arrows it will be noticed that the countershaft (22) and gears (23, 21, 20) thereon are free to revolve.

Low or 1st speed: the gear shift lever (1) is brought to the center, and then drawn sidewise until the lower end of lever engages with shift bar which oprates (6). This gear (5) is then moved into mesh with gear (21). The power then is from gear (9) to (SS), thence (21) to gear (5), thence square shaft to propeller or drive shaft.

Intermediate or 2nd speed—is obtained by returning the gear shifting lever to "neutral" (straight up and down, position illustration shows lever now); then putting end of shift lever (1) in shift bar which connects with (7). Push lever forward, this will slide gear (8) into mesh with gear (23). Note dotted lines then for the transmission of power.

High or 3rd speed—also called "direct" drive: Pull lever (1) straight back. This will shift sliding gear (8) **over** gear (9).

The drive is then direct through gear (9) and gear (8), through square shaft to rear axle. The action causes gear (9) to partially mesh inside of gear (8), as gear (8) is fitted wiht internal teeth. The former method was by means of "dogs" (139), fig. 2, chart 23.

The engagement of these two gears cause the top transmission or square shaft to be engaged direct with the clutch shaft and continuous right through to rear axle.

During the time that the direct drive is on, it will be noticed that the countershaft or secondary shaft (22) although doing no work, is still running. In a few instances, makers have arranged that this should be thrown out of action as soon as direct drive is on, but owing to the difficulty in connecting it up again when the second speed is wanted, it is now generally allowed to remain in mesh.

*__Reverse__: When the "reverse speed" is required the gear shift lever is brought to "neutral," then pushed forward to mesh gears (5 and 20). There are now five gears in operation instead of only four, as for first and second speeds, and the result is that the square shaft (4) turns backwards.

---

*The reverse pinion is set lower down in the transmission case and slightly under the countershaft, hence it is not possible to see it. Changing gear—full instructions also given under instruction 34.

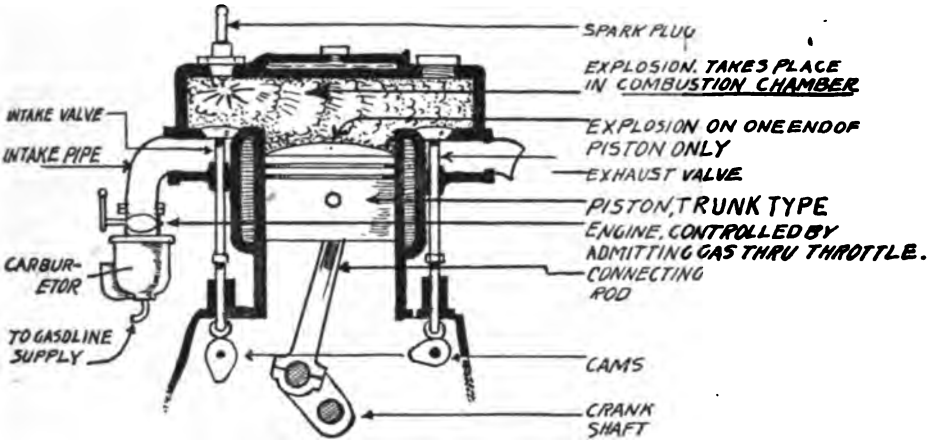

SPARK PLUG
EXPLOSION. TAKES PLACE IN COMBUSTION CHAMBER
EXPLOSION ON ONE END OF PISTON ONLY
EXHAUST VALVE
PISTON, TRUNK TYPE
ENGINE, CONTROLLED BY ADMITTING GAS THRU THROTTLE.
CONNECTING ROD
CAMS
CRANK SHAFT
INTAKE VALVE
INTAKE PIPE
CARBURETOR
TO GASOLINE SUPPLY

Fig. 1—The Gasoline Engine; an **internal** combustion type.

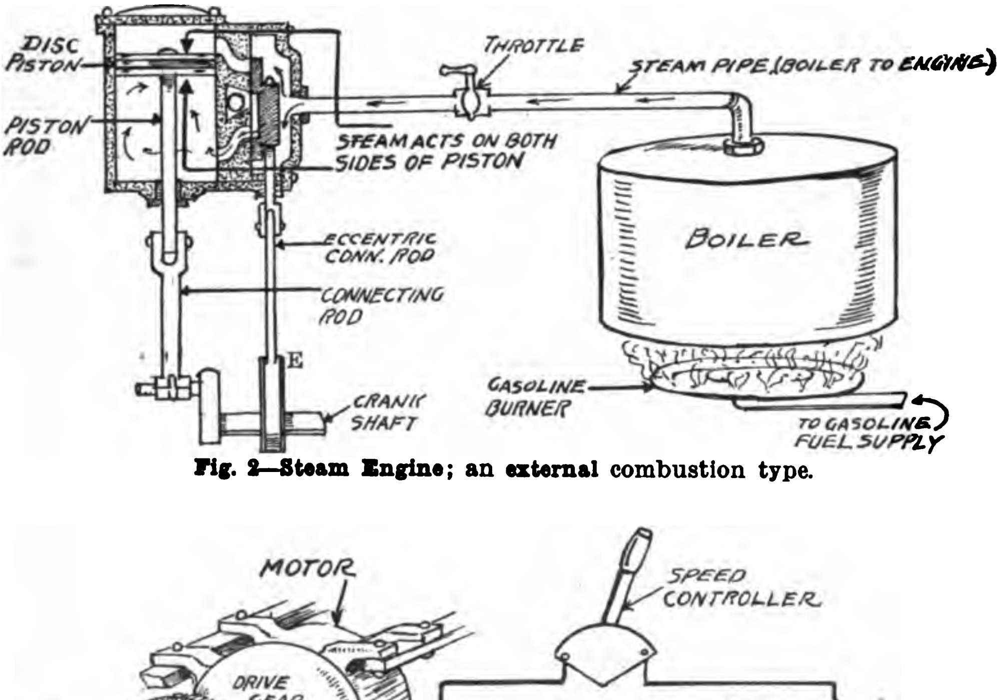


Fig. 2—Steam Engine; an **external** combustion type.

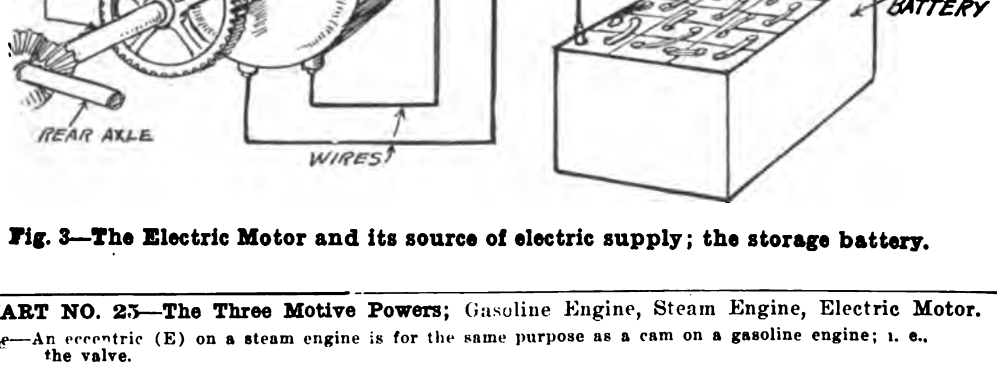


Fig. 3—The Electric Motor and its source of electric supply; the storage battery.

CHART NO. 25—The Three Motive Powers; Gasoline Engine, Steam Engine, Electric Motor.

Note—An eccentric (E) on a steam engine is for the same purpose as a cam on a gasoline engine; i. e., the valve.

INSTRUCTION No. 7.

*THE GASOLINE ENGINE: General Explanation. Cycle Principle Explained. Construction of the Gasoline Engine. Assembling a Four Cylinder Engine. Speed Control of Engine.

General Explanation.

There are three motive powers for automobiles. (1) the **gasoline engine,** also called an ****internal combustion type of engine** in which the fuel combusts inside of the engine, between cylinder head and piston or the combustion chamber. This type of engine could use either gasoline, kerosene or alcohol, but in this treatise we will deal with gasoline as a fuel. (2) **the steam engine** is an external combustion type. The combustion taking place under the boiler, separate from the engine. (3) **the electric motor** (shown in chart 25), derives its power from an electric storage battery.

Gasoline engines: We will deal with the gasoline engine type of automobile. The gasoline engine furnishes the motive power to drive the automobile.

Engines for small cars are sometimes made with but one, or perhaps two cylinders (now obsolete). A few motor cars formerly had engines of three cylinders. The majority have four, six and eight. Five-cylinder engines hardly exist. Seven-cylinder engines exist in a special form for flying machine, as the Gnome revolving cylinder type. The †twelve-cylinder engine is also coming into prominence; motor boats indulge in engines with as many as 12 to 24 cylinders. But whether the engine has 1 or 24 cylinders, the explanation of how it works or the principle, always remains the same.

All gasoline engines work on practically the same principle. It must be a four cycle or a two cycle type (four cycle is dealt with in this instruction). The valve arrangement may be different, but we describe the various types of valves further on in this instruction. The ignition may be different, but we cover all forms of ignition. We mention this so that when you see an engine with a different ignition or a different valve arrangement, remember the principle is just the same on all engines (except the two cycle type, which have no valves. The principle of combustion and ignition is similar, however).

Gasoline engines belong to the class known as **internal combustion** type of engine. This name is used to distinguish them from **steam engines,** which are of the **external combustion** class, for the heat that a steam engine turns into power is produced **outside** the engine, under a boiler.

In a gasoline engine, the combustion, or in other words, the burning of the fuel, takes place **inside** of the cylinder of the engine, the fuel being gasoline.

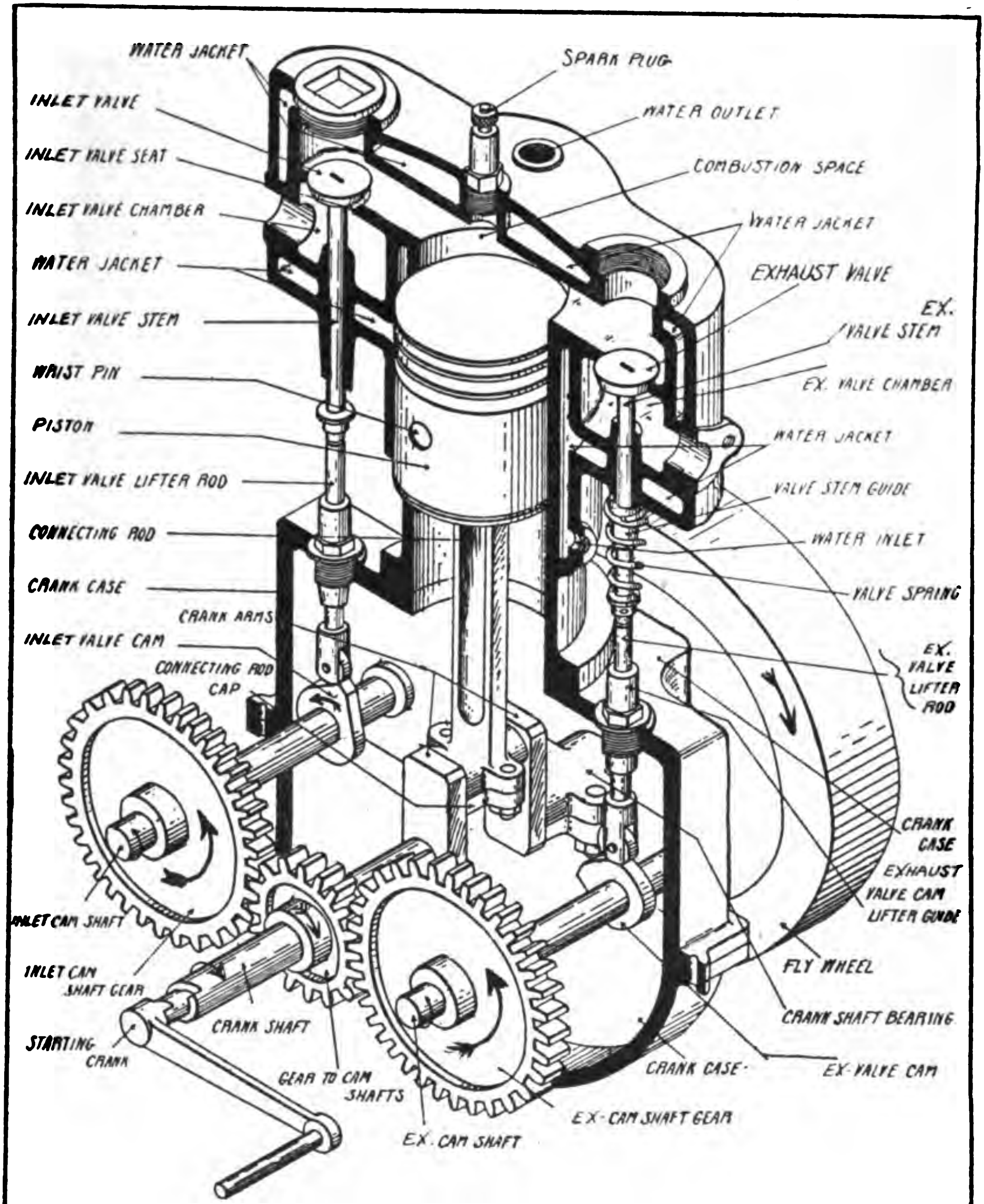
When a mixture of gasoline vapor and air is set on fire, it burns with great rapidity and produces intense heat, which expands and develops the pressure that operates the engine. This combustion is so rapid that it is usually spoken of as an **explosion**; and that word is often used, although the word **combustion** is more correct.

---

*For engine repairs and adjustments. see subject of repairing. **The gasoline engine is also called a "hydrocarbon" type of engine.

†The "twelve" cylinder engine was formerly referred to as the type used on motor boats, where the twelve cylinders were in line. The "twin six" is referred to as the type used on automobiles, with cylinders placed "V" type. However, both terms are used. "Twelve or eight cylinders 'V' type," would be the proper term.

*Note—The word motor is often used to designate the engine, but if one wishes to be technical and correct it should always be referred to as engine. The word "motor," however (owing to the popular practice), is used in many instances in the book.



The Four Cycle Gasoline Engine and Its Parts

When in doubt as to the names of any parts of the engine refer to this chart

The type of valves (both intake and exhaust) on this engine are called "mechanically operated valves."

The type of cylinder is the "T-Head type," with the exhaust valves on one side and the intake valves on the opposite.

CHART NO. 26—A Four Cycle Gasoline Engine Showing a Sectional View T-head type cylinder, valves are of the poppet type and are mechanically operated. With the T-head type of cylinder the intake valves are placed on one side and the exhaust lves on the other side—therefore two cam shafts and two cam gears are required.

for Two Cycle Engines

The difference is that an explosion is instantaneous, while the combustion of gasoline vapor and air, although very rapid, is not instantaneous. The combustion takes place within the cylinder of the engine.

One end of the cylinder is **closed,** and the other is **open,** the closed end being called the **cylinder head.** Within the cylinder is a **piston,** sliding back and forth.

The space between the piston and the cylinder head is called the **combustion chamber.**

The back-and-forth motion of the piston in the cylinder is called **reciprocating motion.** In order that it may turn the wheels, this reciprocating motion must be changed to the motion of a wheel revolving on its axle, which is called **rotary motion.** The reciprocating motion of the piston is changed to the rotary motion of the wheels by means of a **crank shaft.**

The piston is connected to the crank shaft by a **connecting rod,** so that it moves in and out as the crank shaft revolves. One complete turn of the crank shaft, by which the piston is moved from one end of the cylinder to the other, and back again, is called a **revolution.** One-half of a revolution of the crank shaft moves the piston from one end of the cylinder to the other, and this is called a **stroke.**

It must be remembered that **there are two strokes of the piston to every revolution of the crank shaft**; one **down**-stroke and one **up**-stroke.

A steam engine is called double-acting, because the pressure of the steam acts on both sides of the piston.

A gasoline engine is called single acting, because the pressure acts on only one side of the piston; on the top or side nearest to the cylinder head.

The combustion that causes the pressure that operates the engine, takes place between the cylinder head and the piston, in the combustion chamber. The combustion should be timed to occur so that the greatest pressure is exerted when the piston is nearest the cylinder head. The pressure causes the piston to slide the length of the cylinder, from the head toward the open end.

In a steam engine, the pressure of the steam forces the piston to slide first one way and then the other.

In a gasoline automobile engine the pressure from the combustion acts on only one side of the piston, forcing it to slide only one way. After being forced downward, the piston must be brought upward again, and this is done by a heavy ***fly wheel** attached to the crank shaft. With the downward motion of the piston, the fly wheel starts revolving. When once started, the fly wheel continues to revolve until friction or some other resistance stops it, but before this can happen the pressure is again exerted, keeping it going.

†The fly wheel being attached to the crank shaft, they revolve together, and because the piston is connected to the crank shaft by the connecting rod it moves with them. The piston moved downward by the pressure, starts the crank shaft and fly wheel, and then the fly wheel in continuing to revolve moves the crank shaft and piston.

Because a gasoline engine does not operate with continuous pressure, during its action the piston first moves the crank shaft and fly wheel, and then the fly wheel and crank shaft move the piston.

Before there can be a combustion of mixture in the cylinder, the mixture must be drawn into the cylinder, through the **inlet** valve.

When in the cylinder, the mixture must be prepared, so that it **ignites,** burns and expands with the greatest possible rapidity and heat.

---

*Larger fly wheels are used on single cylinder engines than on multiple cylinder engines, because there are not as many firing impulses to two revolutions of crankshaft on a single cylinder engine.

†The fly wheel is usually fitted securely to tapered end of crankshaft and flange. per (92) page 62. It must be secure, else a knock would occur, per page 638.

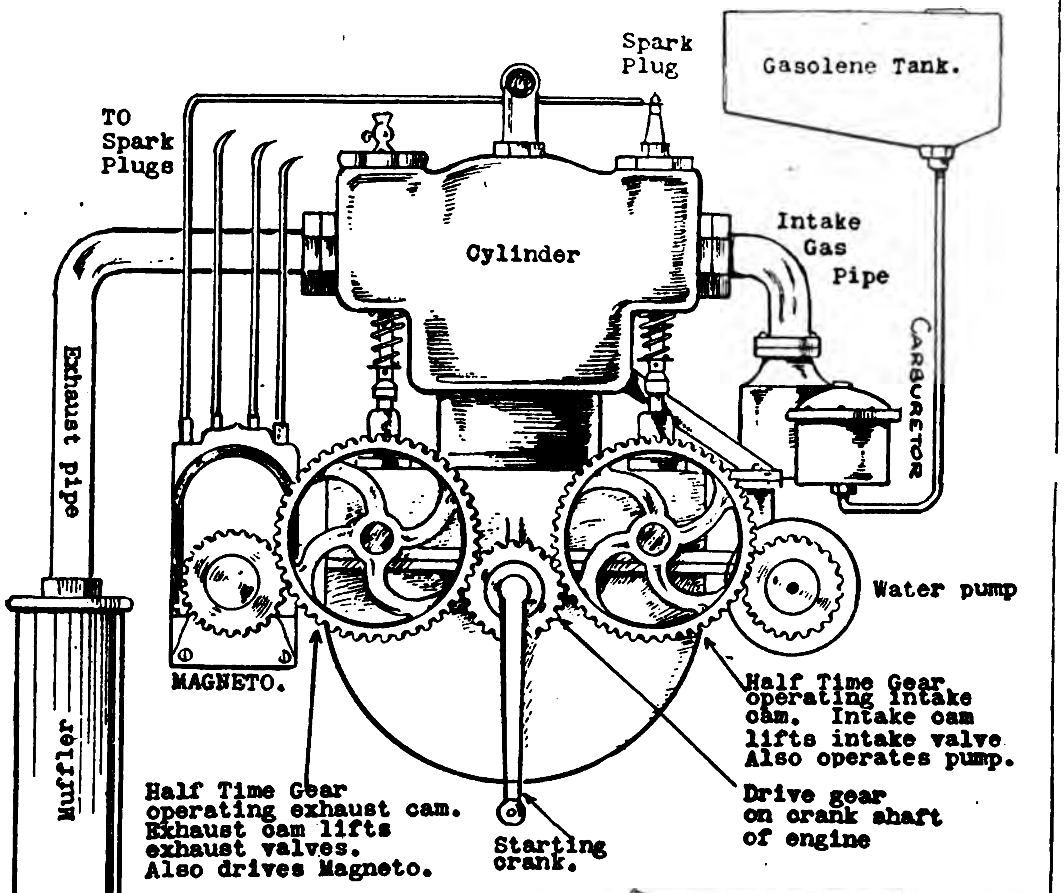

Spark Plug
Gasolene Tank.
TO Spark Plugs
Cylinder
Intake Gas Pipe
CARBURETOR
Exhaust pipe
Water pump
MAGNETO.
Muffler
Half Time Gear operating intake cam. Intake cam lifts intake valve Also operates pump.
Drive gear on crank shaft of engine
Half Time Gear operating exhaust cam. Exhaust cam lifts exhaust valves. Also drives Magneto.
Starting crank.

Fig. 1—Front end of Engine.

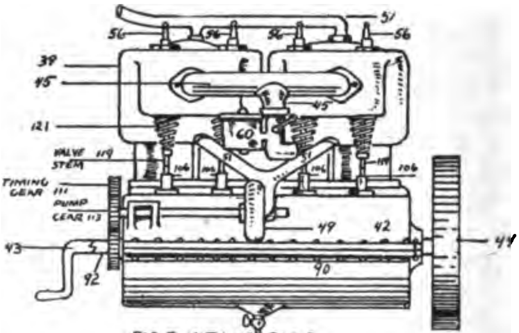


FIG 3 INTAKE SIDE

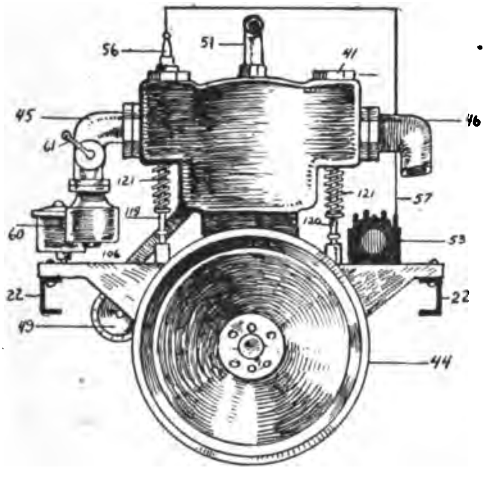


FIG. 2. FLY WHEEL END OF ENGINE

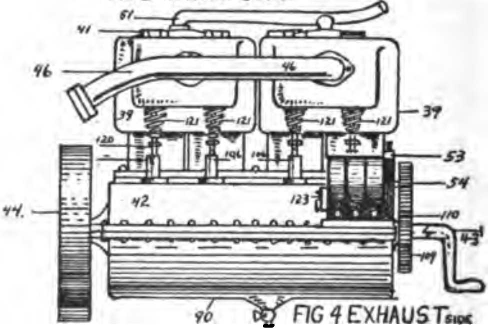


FIG 4 EXHAUST SIDE

HART NO. 27—Different Views of the Outside of a Four Cylinder Gasoline Engine with cylinders cast in pairs. Valves are mechanically operated. Exhaust valves on one side and the intake valves on the other side. Ignition by magneto. Water circulation by pump.

TE—This "T" head type of engine could be constructed with the inlet and exhaust reversed if necessary. nstance, inlet could be on the right side of engine and exhaust on the left side, as shown in chart 26. 8 on page 60).

After the mixture has been burned, the useless gases must be removed, or **exhausted** from the cylinder, to make room for a fresh charge of the mixture.

These successive events must occur in their proper order, for if any one of them fails, or it is not performed properly, the following event cannot occur, and the engine will stop running. ***These events are called a cycle.**

The Four Cycle Principle.

There are two distinct cycle principles; generally spoken of as "four stroke cycle" and "two stroke cycle" principles. The two cycle engine is generally a small marine type of engine and will be dealt with under marine engine instruction.

The four cycle engine is the type used for automobile work, therefore we will deal with this type throughout the automobile instruction.

The cycle is thus composed of: **1st,** the drawing into the cylinder of the mixture; **2d,** the compression of the mixture; **3d,** the burning or ignition of the mixture and the forcing downward of the piston by the pressure produced by the burning of the mixture; **4th,** the removal of the burned and useless gases left after the combustion.

The cycle is performed during two revolutions of the crank shaft, or, what is the same thing, **four strokes of the piston.**

The first event occurs while the piston makes a **downward stroke,** during which the cylinder is sucked full of the mixture, just as a similar stroke of a pump or syringe sucks in a liquid: this is called the **inlet stroke or suction stroke.**

The next stroke of the piston is an upward stroke, during which the mixture sucked into the cylinder is prepared by being compressed, and at the end or top of this stroke it is set on fire, or ignited: this is called the **compression stroke.**

When the compressed gas is ignited the pressure from the combustion forces the piston to make a **downward stroke**; this is called the **power stroke.**

The next upward movement of the piston pushes the burned and useless gases out of the cylinder: this is called the **exhaust stroke.**

In principle the gasoline engine is like a gun. In a gun the shot is fired by exploding powder behind it—in a gasoline engine we explode gasoline behind the piston in exactly the same way.

There are some differences, of course When the charge goes out of the gun, that is the end of it. But in a gasoline engine, after the explosion drives the piston before it, in order to get any work out of the machine, this piston must come back and a new charge must be exploded behind it. The burnt gases and heat must be disposed of and all of these things must be done over and over again very quickly at exactly the right time.

Valves are arranged to open and close at the proper time **to admit fresh gas** and to **let out the burned gas,** and the positions of the piston, valves and cams for each function are shown on chart 29. Note the direction in which the **cams** are turned by the cam gears.

Explanation of The Four Strokes.

Fig. 1: In the first diagram, chart 29, the piston is at the beginning of the **down stroke** on **suction,** and the arrows show the direction in which it is moving.

Fig. 2: In the second diagram, the piston has completed its suction stroke and is now starting **up** on its **compression stroke.**

---

*The word Cycle really refers to the complete operation of the four strokes of piston to complete the cycle evolution. Therefore to distinguish the engine with four movements of piston. from the engine with two movements of pistons to complete the cycle evolution, we will call them: "four cycle" and "two cycle" types of engines.

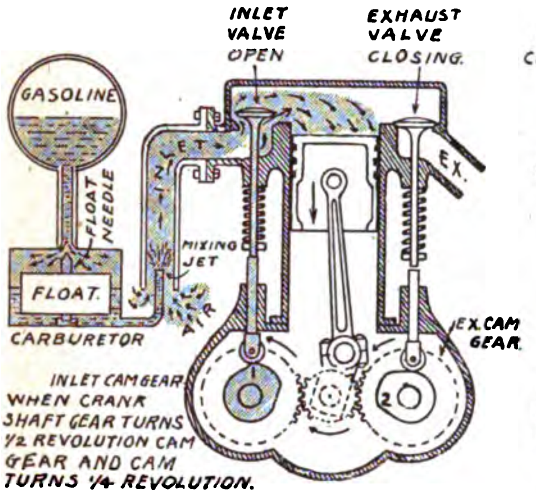


FIG 1. SUCTION STROKE DOWN

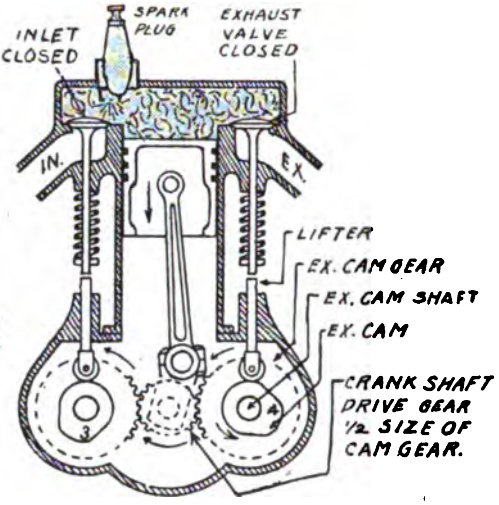


FIG 3. POWER STROKE DOWN.

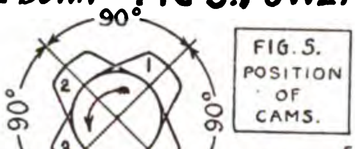


FIG. 5. POSITION OF CAMS.

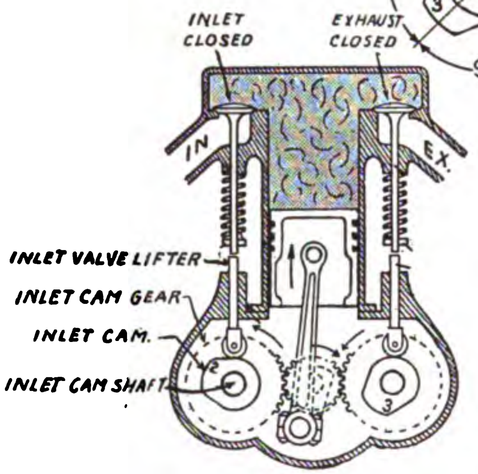


FIG. 2 COMPRESSION STROKE UP

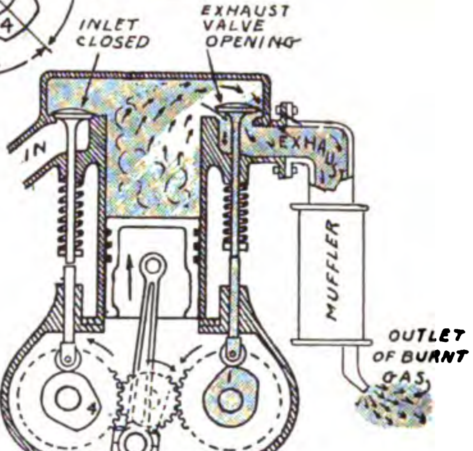


FIG 4. EXHAUST STROKE UP.

Fig. 1. Suction stroke; note charge of gas being taken into cylinder from carburetor by the suction of piston through the open inlet valve.

Note inlet valve opened by inlet cam. Note direction of travel of cam, also note this stroke is also called "admission" or "inlet" stroke.

Fig. 2. Compression stroke; note both valves are closed because nose of cam is not raising either of the valves. Note travel of cam.

Fig. 3. Power stroke; note the spark is now occurring, therefore the compressed gas is combusting. (See page 61, note in actual practice, spark occurs before combustion takes place.) Both valves are closed. This stroke is also called "explosion" or "working" stroke.

Fig. 4. Exhaust stroke; note the exhaust valve cam is now raising the exhaust valve. The burnt gas is being forced out the exhaust pipe through muffler. This stroke is also called "scavening" stroke.

When piston reaches top of exhaust stroke the piston will have completed the four strokes, or two crank revolutions, and cam shaft one revolution.

The next stroke is the suction stroke again. These four strokes are repeated over and over again as long as engine runs.

The above explanation of the four strokes is explained with a "T" head type of engine, supposed to be cut in half and standing in front of engine.

The "L" head uses but one cam shaft, there is but one inlet and one exhaust cam for each cylinder. Just the same as a "T" or "round" head cylinder or any type of four cycle engine. The principle is identically the same.

Fig. 5, illustrates the movement of the cam; note the cam moves 90 degrees or one-fourth revolution, each time the crank moves 180 degrees or one-half revolution.

HART NO. 29—The Four Cycle or Four Stroke Principle Explained. See index for "two ycle" engines.

n page 60, Chart 30 on page 70).

Fig. 3: The piston has now completed its compression stroke and the compressed gas is being **ignited** by the spark at spark plug gap. **This ignition** of the gas causes the **combustion to** take place and piston travels **down with force**, the amount of force being governed by the amount of compressed gas which was admitted to cylinder by throttle of carburetor. This **down** stroke is called the **power stroke.**

Fig. 4: The piston has now completed it's power stroke and is coming up on **exhaust stroke,** pushing burned and useless gas out exhaust valve.

Note the inlet valve is raised to admit the **suction of gas** (fig. 1) and **exhaust valve** is raised to permit the burned **gas to be discharged.** During **the** other two strokes (compression and power strokes), the valves are closed.

†**The reason for first cranking an engine to start it** is due to the fact that a charge of gas must first be drawn into cylinder by the suction stroke, then compressed. After the gas is ignited, then the force of the power stroke, **will give** more turn **to the fly wheel which carries** the piston **through the other three strokes** until power stroke is reached again. (See page 116.)

Therefore, during three strokes (suction, compression and exhaust), the **engine is not developing power.** There being only one power stroke out of the four.

In starting the engine with the starting crank, the spark lever (chart 33) must be **retarded** so that combustion occurs when the piston has begun to move downward on the power stroke, otherwise it will fire before piston reaches the top and run backwards for half a revolution termed "kicking or back firing."

Additional Explanations of the Four Strokes.

As explained four events, called the cycle, occur in the cylinder of a gasoline engine during every two revolutions of the crank, or, what is the same thing, during every four strokes.

The strokes of the piston during the events of the cycle (as stated previously), are called the:

1st—"Inlet" or suction" or "admission" or "inspiration" stroke, fig. 1, chart 29. **2d**—"Compression" stroke, fig. 2. **3d**—"Power" or "firing" or "working" or "explosion" stroke, fig. 3. **4th**—"Exhaust" or "scavenge" stroke, fig. 4. These will be described in their proper order.

***Suction stroke**; the inlet stroke is a **downward** stroke of the piston, sucks in the explosive mixture. Note fig. 1, chart 29.

The speed of the engine is governed by the amount of gas drawn into cylinder through the throttle valve of carburetor (page 66). If high speed is desired, it is necessary that all of the mixture possible may be sucked in, for it is clear that if the cylinder is only partly filled not as much power will be developed as would result from a full charge. There must be no obstruction in the inlet pipe to prevent the mixture from entering the cylinder easily, and the inlet valve must open wide enough to admit the full charge. (See chart 28, 33 and 106.)

As the inlet valve is mechanically operated, the cam must be adjusted (by having the inlet cam gear properly meshed with the crank shaft gear) so that it will open the valve promptly as soon as the sucking action of the piston commences, which it is just beginning to do in fig. 1, chart 29. Note the cam is just starting to raise the inlet valve.

If all the openings into the cylinder, as the exhaust valve, the spark plug, piston rings, relief cock, etc.—are not tight, air or gas will be sucked into the cylinder through them at the same time that the charge enters through the inlet valve, and this would destroy the proportions of the mixture.

If the inlet valve does not open **soon enough,** the piston will have made part of its stroke before the charge begins to enter; if it opens too soon, part of the burned gases from the previous power stroke will be pushed into the carburetor.

---

*See Dyke's working model No. 1, of the "T" head type of gasoline engine, and the four cylinder engine model for the "L" head type of engine.

†The piston of a steam engine moves as soon as steam is admitted to the cylinder—because pressure exists in boiler—therefore it is self-starting. There is no pressure in a gasoline engine until it is running—therefore it is not self-starting. The crank shaft must be turned by hand or an electrical or mechanical device.

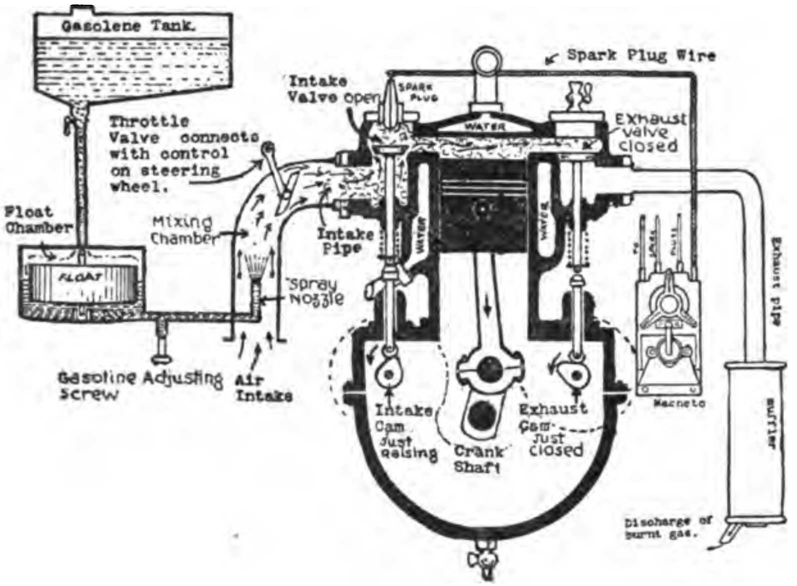
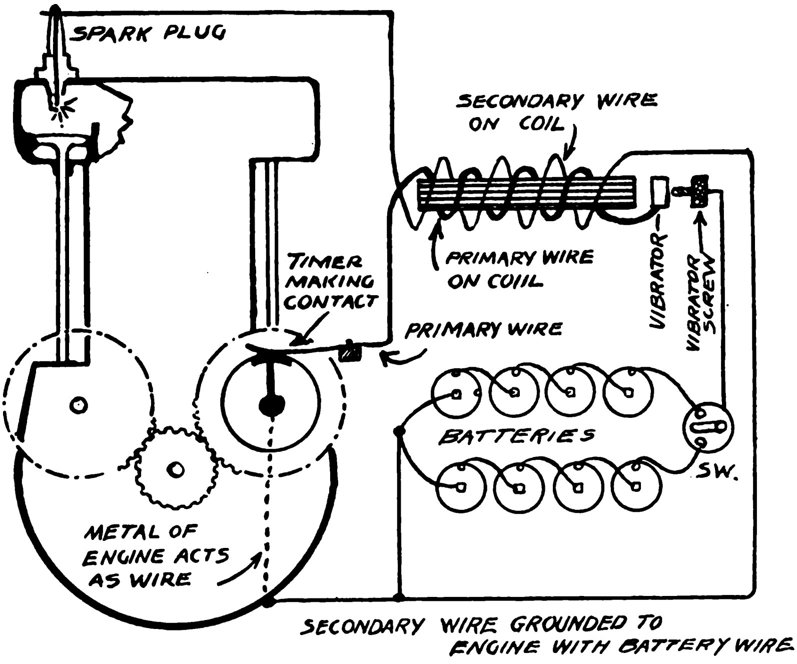


Fig. 1. In this view we are looking at the end of the engine. Imagine end cylinder cut in half.

The object is to illustrate how the gasoline from the tank flows to the carburetor and fills the float chamber until the float needle cuts off the flow. The gas, mixed with air, is then drawn into the cylinder by the suction of the piston on the suction stroke. During this suction stroke the intake valve must be opened by cam (nose shaped affair at bottom of valve lifter) to permit gas to enter cylinder.

After the cylinder is filled with gas, which is the purpose of the suction stroke, the intake and exhaust valves are closed and the piston on its up stroke (compression stroke) compresses the gas. At the highest point of compression the gas is ignited by the spark at the point of the spark plug and the piston is forced down with considerable force; this is called the explosion stroke. As the piston travels up again the burnt gas is expelled through the exhaust valve which should open at this time, and permit the burnt gas to pass out through the exhaust pipe and muffler, this fourth and last stroke to complete the operation, is called the **exhaust stroke.**



The spark occurs at spark plug when piston is almost at the top of compression stroke. (See Fig. 3, Chart 29).

This spark is caused to occur by a coil and battery being connected together at the right time by a "timer or commutator" contact.

The timer arm is revolved by the cam shaft to which it is attached. Therefore it revolves once and makes one contact during two revolutions of crank shaft, if a single cylinder engine. If a four cylinder, there would be four contact segments for arm to touch during one revolution.

If a magneto is used for igniton, as in Fig. 1, then the magneto is run from cam shaft and contact is made by an "interrupter" arm at the right time. See Chart 33.

HART NO. 28—Elementary Principle of Carburetion and Ignition; explaining how the gas is sucked into Cylinder by down motion of Piston and how the Spark is made to occur at the correct time.

Chart 29 on page 58.)

If it closes **too soon**, the cylinder will not get a full charge; if it closes too late, **part of the mixture will be pushed out of the cylinder on the compression stroke.**

†**Compression stroke.** The next stroke **up** of the piston is the compression stroke. As the piston travels up, the mixture cannot escape, therefore it is compressed **until** it occupies only the space between the inside head of cylinder and head of piston.

Power or explosion stroke; at this instant the spark should occur, which ignites the compressed gas causing the piston to be forced **down** with considerable force. This force or pressure is governed by the amount of gas and compression space in top of cylinder when piston is at its extreme up position.

Too poor or too rich mixture will not burn as rapidly as a proper mixture, and **must therefore** be ignited sooner.

In getting the proper time for the **ignition of the mixture**, it must be remembered that it is necessary for the spark to occur at such a time that all of the mixture is to be burned just as the piston is at the top of its stroke—when the gas is compressed to the highest point.

The contact on timer or commutator, or the magneto contract breaker in the ignition circuit, is so arranged (see chart 33), that it may be moved, in order that the spark may occur in the cylinder at the instant desired by the driver; that is, the **spark can** be made to occur **early** or **late** by movement of the hand spark lever. **Advancing** the spark is to move the timer or contact breaker, so that the spark will ignite the mixture (early) before the piston reaches its upmost point in the cylinder. **Retarding the spark** is to move the timer so that the spark occurs **later** in the stroke, in some cases as the piston reaches its upmost position, or even a trifle after.

If the spark is advanced too much, all of the mixture will have been burned before the piston reaches its upmost point, so that it will be necessary for the fly wheel to force the piston upward against the pressure until it gets to its upmost point. This strains the engine, and causes a sound that is called an ignition knock; a hard, metallic sound that may be prevented by retarding the spark.

It is seen from the foregoing that the **speed of the engine may be also controlled** (in addition to the gas throttle lever; see chart 33) **by advancing or retarding the spark,** the speed of the car changing accordingly.

Exhaust stroke: during the exhaust stroke, the cylinder is cleared of the burned and useless gases that are left from the power stroke.

Toward the end of the power stroke, there is still pressure in the cylinder, and when the exhaust valve is opened this pressure will cause the gases to begin to escape.

As the exhaust stroke is an **upward stroke** of the piston, the piston will push out through the exhaust valve all of the burned gases that do not escape by their own pressure.

Back pressure, caused by the muffler or obstructions in the exhaust pipe, will prevent the burned gases from escaping as freely as they otherwise would, and all may not be pushed out by the time that the exhaust valve closes.

If all the burned gases are not pushed out of the cylinder, it will prevent a full charge of fresh gas from being drawn in, which will cause a weak mixture and a weak explosion.

The exhaust valve closes as the piston reaches its upmost point, or a little after it, the inlet valve opening as it closes.

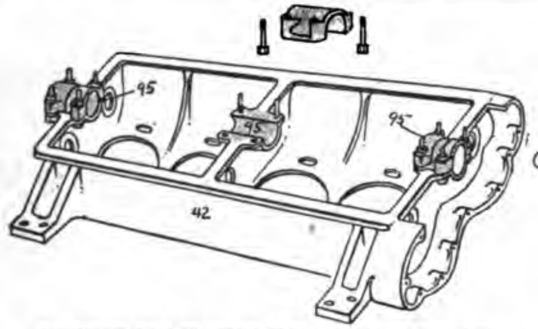
The exhaust valve and its seat are exposed to the full heat and flame of the burning mixture, and are more liable to warp or pit than the inlet valve.

It must be watched, and if there does not seem to be perfect compression when the engine is cranked the probability is that it needs grinding to seat it properly.

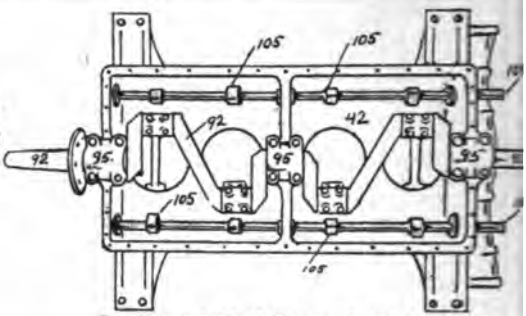
A proper mixture will be entirely burned before the exhaust valve opens. An **improper mixture** that burns slowly, may still be burning when the exhaust valve opens, and will heat the exhaust pipe and muffler so that the pipe may become red hot. Such a mixture wastes fuel, and may result in a fire. It may be corrected by making a **correct adjustment of the carburetor and spark,** which will be explained later on.

---

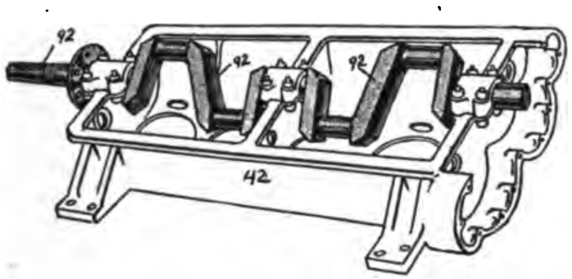
†**Note on word** "compression"—the word "compression" as used by motorists in such terms as "good compression" or "weak compression" refers rather to the compressibility of the engine than to the amount of pressure actually obtained in the cylinder, which, of course, varies very much with the amount of gas admitted to the cylinder during the suction stroke.



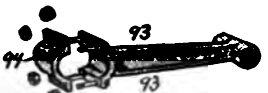
A—Upper half of crank case (turned upside down) showing the lower half of one of the **main bearings** to the side.



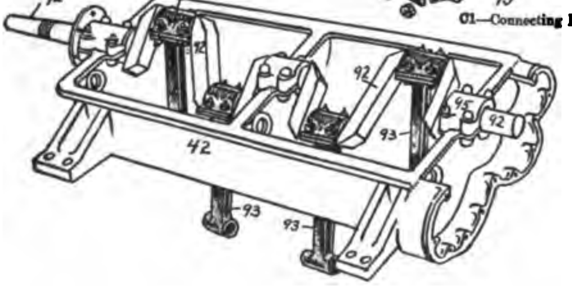
D—Upper half of the crank case (turned upside down) showing **cam shaft.**



B—Upper half of the crank case (turned upside down) showing the **crank shaft** in place in its bearings.



C1—Connecting Rod.



C—Upper half of the crank case (turned upside down) showing the **connecting rods** fitted to the crank shaft.

Key to Engine Parts.

Crank Case—
Upper half (upside down)
Crank case—lower half
Crank shaft (4 cylinder)
Fly wheel
Starting crank
Main bearings

Connecting Rods
Crank pin bearing
Wrist pin

Piston
Piston rings
Piston pin

Cam Shafts
Cams (nose shape, which raise the valves)
Valve plunger guide

Gears—
Drive gear on crank shaft
Cam shaft gear 110-11
Magneto gear
Pump gear

Cylinders—
Cast in pairs—"T" head
Inlet valve caps
Exhaust valve caps
Pet or relief cocks
Outlet water connects with radiator
Studs for cylinders

Pump—(Water circulating)
Intake water connection

Valves—(Mechanically operated)—
Intake gas valves
Exhaust valves
Valve springs

Manifold—
Inlet gas pipe (supports carburetor and passage of gas to cylinders)
Exhaust pipe (passes to muffler and through muffler the burnt gas is discharged)

Ignition—
Magneto, supplies electric current for igniting the gas—run by gear
Magneto distributor
Contact breaker on magneto
Spark plugs

CHART NO. 31—Explaining how a Four Cycle, Four Cylinder Gasoline Engine is Constructed. the reader will start with illustration (A) and study each carefully he will note different parts added until the engine is completed.

NOTE:—The S. A. E. now designate the lower part of crank case as the "oil pan" when containing no bear If it contains bearings, it is termed lower crank case. S. A. E. further designate crank cases of the " type" and the "barrel type."—In the barrel type the crank shaft is removed from one end of crank The bearing caps being removed through hand hole plates. Type shown here and most used is the "split typ with the bearings completely in the upper half as at (A).

(Chart 30, see page 70.)

Types of Engines.

As previously mentioned there are several types of engines, all of which work on the four cycle principle. In order that the reader may more clearly understand we will give an outline illustration of some of the different types of engines in general use, see pages 70 and 71.

The type of engine used more than any other type for automobile work, is the **four** and **six,** the **eight** and **twelve** V cylinder type of engines are also popular. We will confine our attention, however, principally to the **four.**

Building a Four Cylinder Engine—showing the construction, step by step.

Before the reader can thoroughly grasp the meaning and purpose of the parts, we will build up a four cylinder T-head type of engine as shown in charts 31 and 32. We shall then describe what each part is for, and the various constructions of the different parts by different manufacturers.

***Crank case:** by referring to fig. A, we have an aluminum crank case, upper half part, which we lay on the floor, upside down, so that we can see the bearings (95).

The bearings are made in two halves. The bearings are usually made of bronze or white metal and are termed "bushings" instead of bearings when removable or renewable. The bushings are fitted into bearing caps.

Shims (thin paper or metal strips) are placed between the two halves of the bearing so that when wear occurs a "shim" can be taken out and the lost motion taken up. See index.

The crank shaft (92, fig. B), will now be fitted in the bearings. The bolts are tightened so that there is no lost motion.

The connecting rods (93, fig. C), will now be fitted to the crank shaft. The lower half of the large end of the connecting rod, called the connecting rod cap, is removed, so that it can be fitted to the crank shaft. It is then tightened carefully, and shims inserted so that it works free on the crank shaft, but good and tight, so that there will be no lost motion. If there was lost motion a knock or pound, which would cause wear, would be the result.

The cam shaft (104, fig. D), with the four cams (105, nose shaped) are now fitted to its bearings. In this engine there are two cam shafts; one with four cams for raising the four inlet valves, and the other one, with its four cams (105) to raise the four exhaust valves.

The nose of the cams are so placed that they are divided equi-distance apart so that when they revolve they will raise the valves, by pushing them up with their nose, at a certain given time. The timing gears which operate the cam shafts, will be explained further on.

The crank case, is now turned right side up, after having fitted the lower half of the crank case (90) (oil pan). This lower half holds the oil, which the crank shaft splashes in (lubrication systems explained farther on).

The piston or wrist pin (96, fig. E), in small end of connecting rod, is shown in the next illustration. This holds the piston to the end of the connecting rod (details of each part will be explained further on).

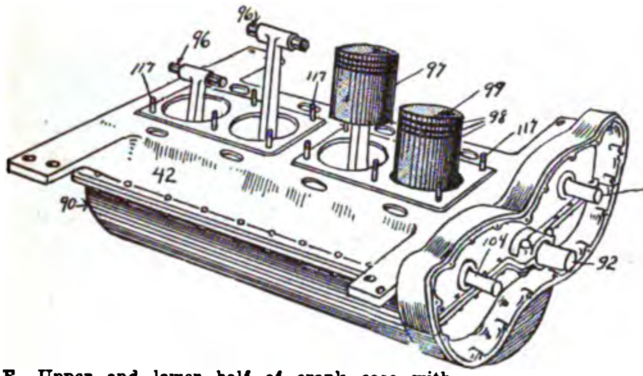
After the four pistons are fitted to the connecting rods, the cylinders (39, fig. F), are fitted down over the pistons, being careful not to break the piston rings (98, fig. E). (Treated under repair section.)

The cylinders (39, fig. F) are bolted to the crank case by nuts fastening to studs (117, fig. E).

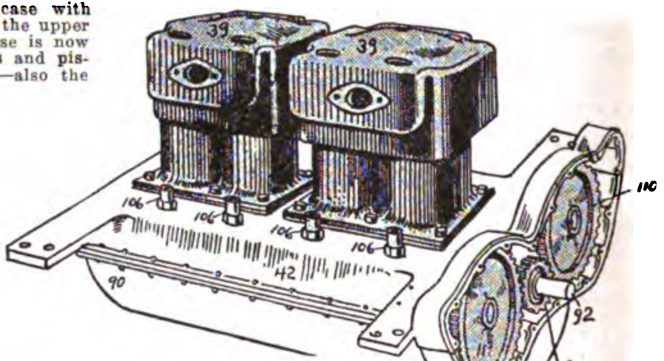
The valve lifter guides (106, fig. F) are fitted in holes in each side of the crank case that they will come in line with the exhaust valves on one side of the cylinders, and the inlet valves on the other side.

---

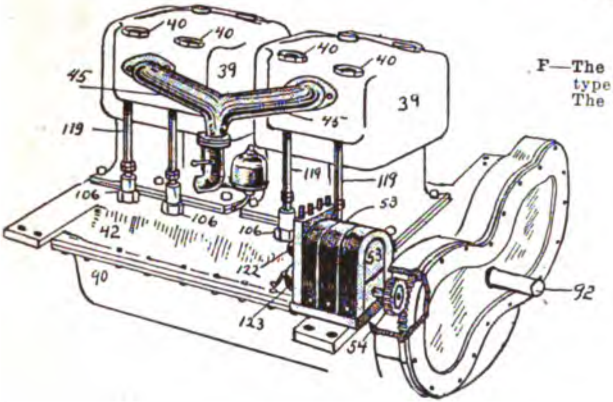
*Technically the term "crank case lower half" should be "oil pan" and as the term "crank case lower half" is used only when it contains the bearings, whereas in this and most engines the lower half is merely an oil pan.



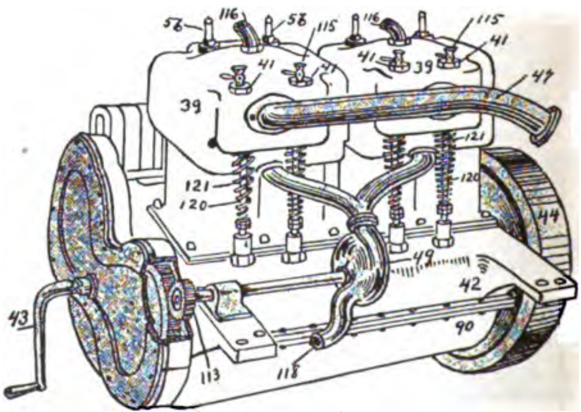
E—Upper and lower half of crank case with lower half of crank case bolted to the upper half. The upper half of crank case is now turned right side up. The **pistons** and **piston pin** or **wrist pins** are shown—also the **studs to hold cylinders in place.**



F—The cylinders (cast in pairs—"T" head type) are now bolted to crank case. The **valve plunger guides** are also fitted.



G—This view shows the intake valves in cylinders, intake pipe with carburetor fitted to cylinders, also magneto mounted and geared to one of the cam gears.



H—Shows exhaust valves (opposite side of engine) with exhaust pipe, relief cocks, water circulating pump. The flywheel is also mounted on end of crank shaft.

CHART NO. 32—Construction of a Four Cycle, Four Cylinder Gasoline Engine, Continued. Carburetor, ignition and water circulating system added.

Valve lifters are now fitted through these valve lifter guides (see chart 26), which raise the valves through the action of the cams.

The gear for driving the timing gears, called the crank shaft timing gear (109), is keyed or threaded to end of the crank shaft (92); this gear drives the two timing gears (110 and 111).

***The cam shaft timing gears** are keyed to the cam shaft (104), one gear and shaft to operate the inlet valves (119), fig. G, and the other gear and shaft to operate the exhaust valves (120), fig. H. The gear case is filled with grease and a cover is placed over the gears. (On modern engines the gears run in oil.)

The inlet valves are placed in their seat by letting them through the inlet valve cap holes (40).

The exhaust valves are placed in position, on the opposite side of the cylinders, in the same manner.

The inlet manifold (45) fig. G, is now bolted to the inlet valve side of the cylinders, and the carburetor is connected to it.

The exhaust manifold (47) fig. H, is bolted to the exhaust side of the cylinders, and is connected with muffler (48) at rear of car, by the exhaust pipe (47); see chart 5.

The exhaust valve caps (41) and the inlet valve caps on the opposite side are now screwed in place—tightly.

The priming cups also known as compression or relief **cocks** (115) fig. H, are screwed into the exhaust valve caps.

The spark plugs (56) are screwed into inlet valve caps or in center of each cylinder as per page 54, but usually over inlet valves.

The fly wheel and starting crank (44-43) are fitted to each end of the crank shaft. By referring to fig C-92, the reader will note the end of crank shaft tapers, and a flange is also turned on this crank shaft. The fly wheel fits to this taper and bolts to the flange, as there positively must not be any lost motion.

The magneto (53) fig. G, is bolted in place on a brass base provided for it, on the side of the engine. An extra gear (which will be explained further on) is operated by the cam shaft and drives the magneto, which generates electricity. The electricity is distributed to the four spark plugs (56) at certain periodical times by the distributor on magneto (122) fig. G.

We now connect our wires through switch (55, see chart 1) to magneto. This switch is to cut off or turn on the electric ignition.

The circulating pump (49) is connected to the water jacket of cylinders. The gear (113) driven by the cam gear, drives the pump, and keeps the water in constant circulation, which keeps the cylinders from getting too hot, not over 170 to 180 degrees Fahr. We now connect rubber hose (51) to metal pipes on radiator (50), see chart 1, and also to our pump (49) and belt up our fan (52), which is run from the same shaft. **The radiator** is filled with water by unscrewing cap (56, chart 1).

We now connect the gasoline fuel pipe (62) from gasoline or fuel tank (58, see chart 1) with carburetor.

†Starting the Engine.

We now have our engine ready to run (we will presume it has been fitted to car as shown in chart 1).

We now put the gear shift lever in "neutral" position, so the car will not move when the engine begins to run.

The starting crank is revolved, which turns the crank shaft, timing gear and moves the pistons, (see chart 26). The crank shaft timing gear revolves the cam gears which in turn revolve the cam shaft, and which in turn revolves the cams.

When the cams turn, one of them with its nose pushes up one of the eight valves in one of the four cylinders. (There is one intake and one exhaust valve for each cylinder.) **We will suppose that this valve being raised is the inlet valve of No. 1 cylinder.** As this valve is raised the piston will be going down on the suction or intake stroke, as explained in fig. 1, chart 29, **and draws in a charge of gas.**

---

*The gears are timed as shown under valve timing.

†See page 59 why it is necessary to start a gasoline engine.

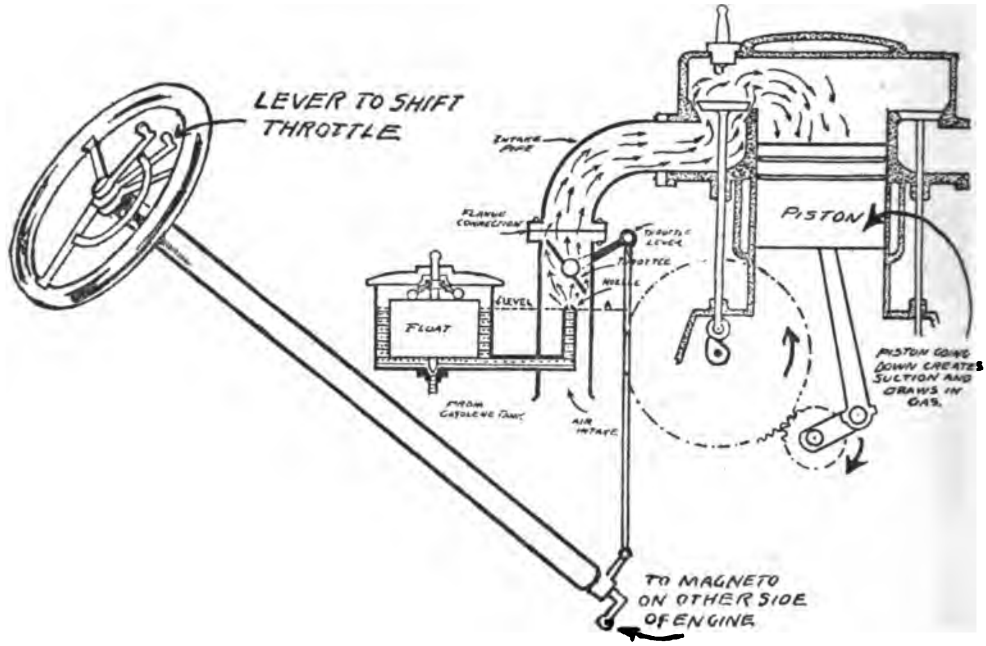


Fig. 1.—Illustrating the principle of opening and closing the throttle valve on the carburetor by the throttle lever on the steering wheel.

See Chart 8 and note Fig. 68 and follow the rod leading through the steering column (63) and note how it connects at (72), with carburetor.

Opening the butterfly throttle valve on the carburetor admits more gas into the cylinder, thereby increasing the speed. Closing this valve reduces the speed.

At the same time the throttle lever is "advanced," the spark lever, which shifts the contact breaker on the magneto, is "advanced" also.

If a timer with a coil system of ignition is used, then the spark lever (see page 60) shifts the timer instead of the contact box on magneto.

The object in advancing the ignition as the throttle is opened, is to cause the gas to ignite earlier—which is explained on page 67.

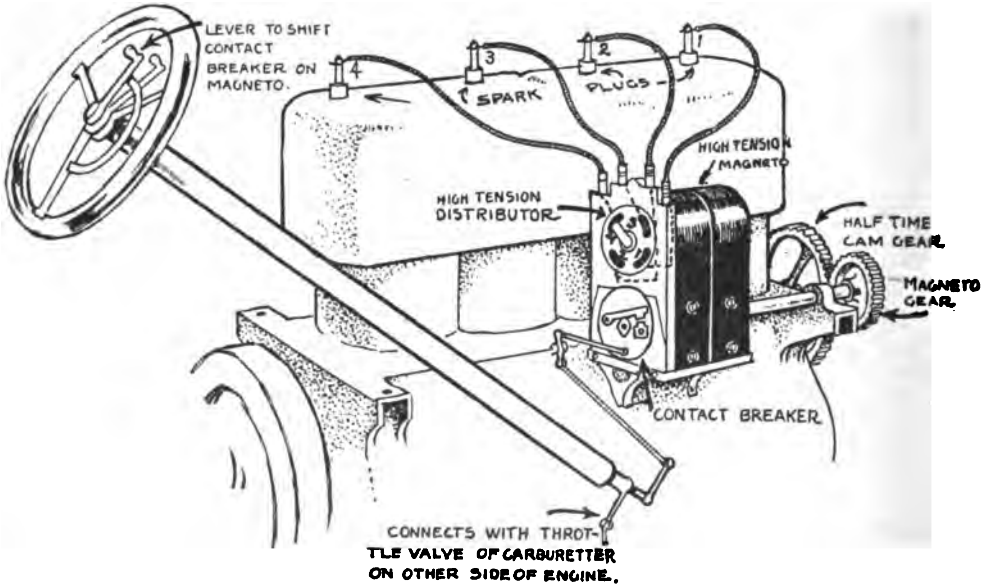

LEVER TO SHIFT CONTACT BREAKER ON MAGNETO.
4
3
2
1
SPARK
PLUGS
HIGH TENSION MAGNETO
HIGH TENSION DISTRIBUTOR
HALF TIME CAM GEAR
MAGNETO GEAR
CONTACT BREAKER
CONNECTS WITH THROTTLE VALVE OF CARBURETTER ON OTHER SIDE OF ENGINE.

CHART NO. 33—Elementary Principle of Control of Speed of Engine; explaining the action of the throttle and spark.

The suction stroke is now completed; the gas which was drawn into the cylinder must now be compressed. **Just as it is compressed,** the electric **spark occurs** at the point of the spark plug and ignites the gas.

At the moment the gas is ignited, the force of the explosion forces the piston down and this force gives momentum to the fly wheel, which will keep the crank shaft in motion until another piston in one of the four cylinders has drawn in and compressed its gas and fired. **The cycle operation** explained in chart 29, is **repeated over and over** again in each cylinder. (See page 116, how a 4 cylinder engine fires.)

Control of Speed of Engine.

After the engine is started with starting crank (self starters will be explained further on), the **speed of engine is controlled** by opening and closing the throttle of the carburetor which, when opened admits gas to the cylinder. The **more gas admitted** the stronger the explosive force will be, hence **more speed.** The gas of course, is admitted through the inlet valve during the suction stroke.

The opening and closing of throttle is regulated **by hand** by means of the throttle lever (fig. 1, chart 33 and 106) on the steering wheel, or by a foot pedal connected with the same throttle lever called an "**accelerator.**" (See index.)

Carburetion; the carburetor is connected to the inlet manifold by the inlet pipe, and the gasoline flows to it from the supply tank through a small brass or copper pipe, called **fuel pipe.**

Pure gasoline vapor will not burn, but must be mixed with **air** before it can be used to develop pressure. The mixing of gasoline vapor and air in the proper proportions is called carburetion. To give the best results, the mixture of gasoline vapor and air must always be in correct proportion. (See index.)

There is a passage through the carburetor into which the air is drawn as the piston makes the suction stroke. The liquid flows to the carburetor and is brought into contact with the current of air. The gasoline turns to vapor, and is absorbed by the air, the mixture being sucked into the cylinder on the suction stroke.

The quantity of mixture that is drawn into the cylinder during one suction stroke is called the **charge.** Details of carburetion are given in Instruction 12.

Ignition; when the throttle is being opened and the engine begins to speed up, it is then necessary to also "**advance**" the time of ignition in other words, cause the spark to occur sooner than when engine was running slow.

A spark lever is usually placed on the steering wheel along side of the throttle lever, which is connected by a rod and bell crank to the contact breaker box on the magneto or if a coil and timer is used, to the timer. (See chart 33 and 106.)

When the spark lever is moved, it also moves the contact breaker box on magneto or commutator, which causes the spark to occur "late" or "early" according to the movement of this lever, (chart 33).

The reason for advancing the spark is as follows: To begin with, the charge is set on fire, or ignited, at the proper time by an electric spark.

The current of electricity that supplies the spark is produced by a battery, or a magneto or dynamo driven by the engine.

The exact instant for the ignition of the charge depends on the kind of work to be done, the speed of the engine, and the quality of the mixture. If the charge is ignited **too soon** or **too late,** the engine will not run properly.

The time of ignition, or instant when the electric spark sets fire to the charge **is controlled** by means of a **commutator, timer or contact breaker** which is advanced or retarded by the driver by means of a spark lever on the steering wheel.

We have up to this time supposed that the spark occurs exactly at the moment when the piston reaches the top of the compression stroke. Now, this would be its correct timing were it not that the gas takes quite an appreciable time to explode after being ignited, an interval let us say of 1/240 of a second, so that before the gas has had time to burst into a full explosion, the piston, on account of its great speed (suppose it is traveling at 1,500 revolutions per minute), will have traveled about a quarter of a stroke down the cylinder before being affected by it. This means a quarter of every power stroke wasted.

***The advance of spark**; the remedy for this is to make the spark occur a quarter of a stroke earlier; that is, make it occur when the piston has completed but three-quarters of the compression stroke so that the full burst of explosion and the piston arrive simultaneously at the top of the stroke, or on top "dead center." This is called advancing the spark.

The retard of spark; suppose the engine is now running at only half the speed, say 700 revolutions per minute. During the exploding or igniting period, which we assumed to be 1/240 of a second, and which remains the same, the piston, with its speed now reduced, has not time to travel so far, and the spark therefore need not be so much advanced.

Again, when the engine runs dead slow, say at 100 revolutions per minute, which is slow for a motor car engine, the spark requires hardly any advance at all. So that we see at once that the **faster** the engine runs the more the spark must be **advanced**, and that the **slower** the engine runs the less it need be advanced, or, to express it in a more usual way, the more the spark must be **retarded.**

Let it be clearly understood that to "advance" or "retard" the spark, means to cause the spark to occur **earlier** or **later** relatively to the position of the piston. It does not mean that the spark is made to occur more frequently or less frequently.

Question.—How can the spark be made to vary as to the time at which it takes place?

Answer.—In chart 33 a device is shown on the magneto which is called a "contact breaker." This is usually placed on the end of the magneto armature shaft which is operated by the cam shaft. It is nothing more or less than what we might call a rotary or revolving electric switch. For instance, suppose the contact is made on dead center, but should it be necessary to advance the spark, the contact breaker can be turned, by means of a spark lever on the steering wheel. This will cause the spark to be turned on earlier or before the piston has reached the top of the stroke.

Question.—Suppose I do not advance the spark when the throttle is opened and engine is running fast, what then?

Answer.—The engine wastes say quarter of every explosion stroke, and fails to run so powerfully as it would were the spark properly timed or advanced.

Question.—What if I advance the spark when the engine runs slowly?

Answer.—Then there will be a fierce struggle inside the engine; the piston fighting to complete the compression stroke, and the explosion, which has occurred too soon, trying to force it back again. And which wins? If the engine is working fairly briskly, the piston overcomes the explosion; otherwise the explosion drives back the piston, and stops the engine

This is why frequently when an engine is cranked it "**kicks back**"; the spark has been advanced too far, and the piston can't overcome the early explosion.

Question.—How can I tell when the spark is too much advanced?

Answer.—There will be a sound in engine as of a hammer striking the top of the piston. The engine will be said to knock, and the more the spark is advanced the louder will be the knock.

---

*Note.—Lag in the explosion stroke is also due to the electrical apparatus producing the spark, see pages 308 and 243. *See also pages 305 to 309.

Question.—And what should make it knock? Does the piston strike the top of cylinder?

Answer.—We have already pointed out that this is impossible, as the length of the stroke is invariable; neither does it appear that it is caused by a general looseness throughout the parts of the engine, since new engines knock as much as old ones.

A possible explanation, and one which has received some support, is that the charge in the cylinder detonates in much the same way as certain solid explosives. A piece of gun-cotton, for instance, if laid upon an anvil and lighted with a match, burns silently, because it has all the space to expand in that it requires, but if instead of its being lighted it be struck with a hammer, it goes off with a loud report.

Now, in the case of the gas exploding in the cylinder, if the piston is able to move away from it easily and thus give room for the expansion, there is no noise, but if, as in the case we are discussing, the piston moves against the explosion, like the hammer falling on the gun-cotton, the result is a report.

The knocking is not always detected easily by the novice, who will probably confuse it with other sounds on the car, but when once it has made itself evident, the spark should be, instantly retarded until the knocking ceases.

The strains set up in an engine which is allowed to knock may seriously damage connecting rods and cranks.

An engine should not be slowed by retarding the spark. If it has been noticed by the reader during the last few paragraphs that it is possible to slow an engine by retarding the spark, let him at once understand that this is the last method by which it ever ought to be done.

It is not only unscientific, but is also wasteful of fuel, unnecessary work for the engine, and causes rapid pitting of the exhaust valves, the gases passing through them in an incandescent form.

The correct method of slowing down or increasing the engine speed is to shut or open the throttle valve, which is situated between the carburetor and the inlet valve, by which the amount of fuel supplied to the engine may be regulated (see illustration, chart 33, fig. 1). Then as the engine varies its speed slower or faster, the spark should be retarded or advanced accordingly.

The rule therefore is to let the engine speed follow the throttle and make the spark follow the engine speed; or to put it in another way, to drive economically, keep the throttle valve closed as much as possible and the spark advanced as far as possible, short of knocking or tendency to knock.

Retarding the spark too much produces heat, see page 319.

Ignition.

Consists of a spark plug, a source of electric supply, which may be either a magneto, generator or battery and coil. If the latter system, then a timer or commutator is used to make contact from the battery to the coil, causing a spark to occur at the points of the spark plug. See fig. 5, chart 39 for an early form of commutator—more modern methods will be treated further on.

The spark plug can be placed over center of piston or side of cylinder if overhead valves. If side valves; over inlet valve—usually screwed into inlet valve caps—see chart 30-A.

Carburetion.

This subject is treated under instruction numbers twelve and thirteen

Cooling.

The explosion of the charge in the cylinder produces **heat.** This heat is so intense that the lubricating oil will burn and be made useless if the cylinder is not kept fairly cool. If the lubricating oil were burned, the friction of the piston against the cylinder walls would be so great that they would cut each other, and the piston would stick, stopping the engine. The cylinder must therefore be kept from heating to the point at which the lubricating oil would burn, but as the heat develops the pressure, the cylinder must not be too cool.

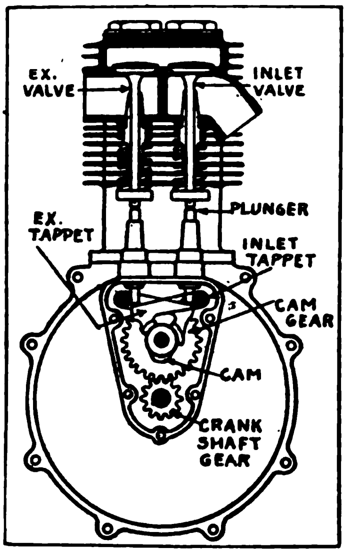
The cylinder may be cooled either by a current of **air**, or by **water** circulating around it. See instruction number fourteen on the subject of cooling.

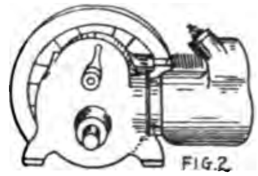
Fuel System.

There are two fuel systems in general use for feeding the gasoline to the carburetor: the **pressure** and **gravity feed**—the two will be explained further on under instruction number twelve.

Lubrication.

There are several methods for lubricating the moving parts of an engine, which **will** be fully treated further on under instruction number fifteen.





-A Single Cylinder Horizontal

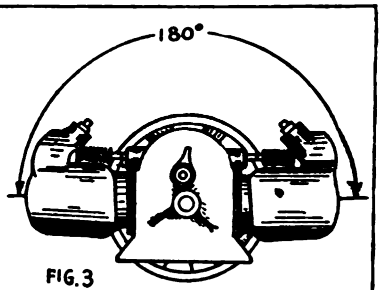
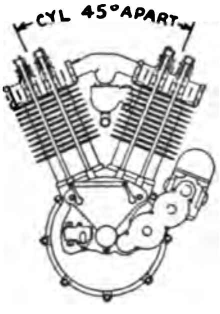


FIG.3

Two Cylinder Opposed Type



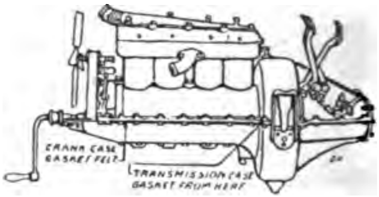


Fig. 1. A single cylinder vertical type of engine, with air cooled cylinder. Valves are both on the side and mechanically operated. There are two fly wheels with a crank pin between them. The fly wheels run inside of the aluminum crank case. This type of engine is used on motorcycles, cycle cars, and railroad light cars.

Fig. 2. A single cylinder horizontal type of engine, with water cooled cylinder. Formerly used on light weight automobiles. Seldom used, valves mechanically operated.

Fig. 3. A double cylinder opposed type of engine, with water cooled cylinders and mechanically operated valves. Note cylinders are 180° apart. Cylinders are "L" type. The crank shaft is also 180° type.

Fig. 4. A twin cylinder "V" type of engine, with cylinders placed 45° apart. Cylinders air cooled. Valves mechanically operated from overhead. Cylinder is the "round" type. This type of engine used on motorcycles and cycle cars.

Fig. 5. A four cylinder vertical type of engine, with transmission and clutch in one housing joined to engine—called a "unit power plant." This engine is suspended in frame at three points, therefore it would be called a "three point suspension" type of power plant. Valves all on one side of the "L" type cylinders.

The cylinders are all cast together or "in block." The cylinder head is in one piece. (The Ford.)

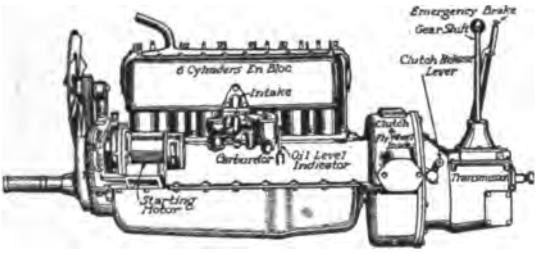


Fig. 6. A six cylinder "unit power plant." Transmission, clutch case join the engine. Cylinders are cast together or "in block."

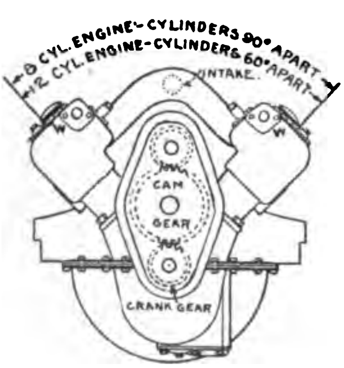

8 CYL. ENGINE-CYLINDERS 90° APART
12 CYL. ENGINE-CYLINDERS 60° APART
INTAKE
CAM
GEAR
CRANK GEAR

Fig. 8. Eight cylinder "V" type engine, with cylinders placed at an angle of 90° apart. One cam gear operates the valves on both sides of the "L" shaped cylinders. There are four cylinders on each side, usually "in block." Crank shaft is a four cylinder type (180°) crank, with two connecting rods to each crank pin.

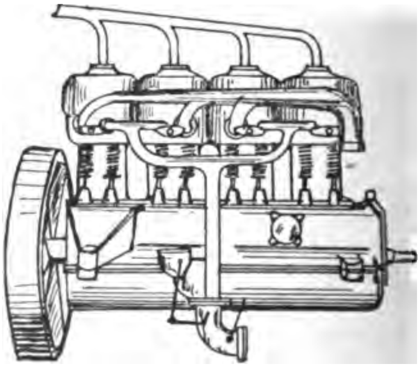
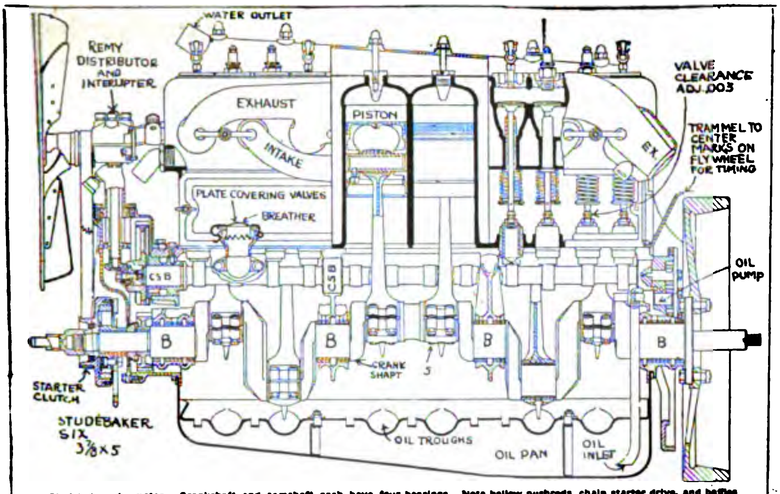


Fig. 7. A four cylinder engine with cylinders cast separate. All valves are on one side; hence "L" type cylinders.

]HART NO. 30—Types of Four Cycle Gasoline Engines.

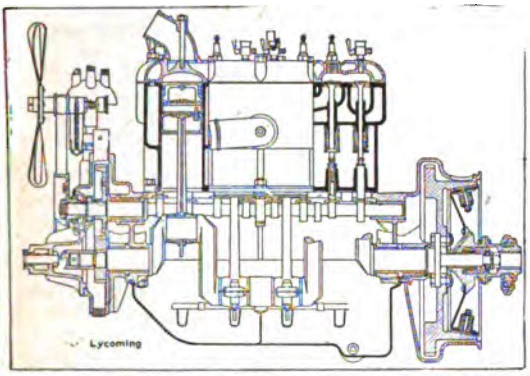
Chart 34 on page 74.



Studebaker six motor. Crankshaft and camshaft each have four bearings. Note hollow pushrods, chain starter drive, and baffles

The Studebaker six cylinder engine, specifications of which are given under "specifications of leading cars" and "standard adjustments of leading cars," is a typical example of a modern six cylinder engine.

The cylinders are "L" type with valves all on one side. The exhaust and inlet manifold are placed on one side. Parts of the engine are lettered. The lubrication is the "circulating splash" system as described under instruction fifteen.

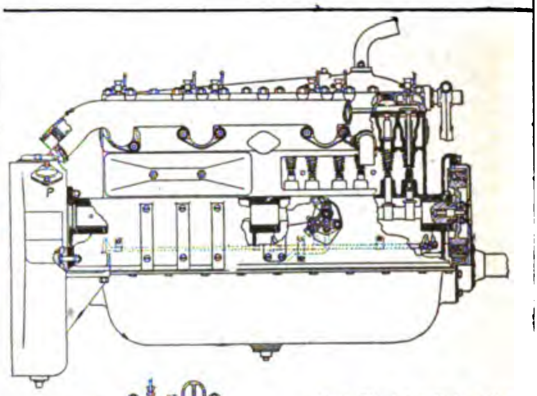


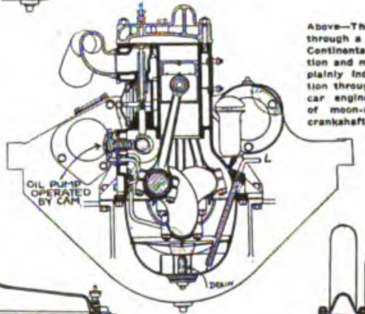
The Lycoming engine is used on several makes of cars (see specifications of leading cars).

The illustration above shows the four cylinder engine with 3¼ inch bore and 5 inch stroke. **Cylinders** cast "in block;" **crank** shaft two-bearing. Note fly wheel bolted to crank shaft flange. A cone clutch is shown in the rim of fly wheel. **Cam shaft** is 1 inch diameter and carried on three bearings. **Timing gears** helical steel; crank shaft gear is steel and cam shaft gear cast iron. Gears are marked for retiming. Valves 1⅜ in. diameter and on right side of engine. Bearings; crank shaft and connecting rod bearings made of die cast white metal, split and are adjustable by removing shims. Oil pockets provided in bearings. **Cooling;** thermo syphon. **Lubrication** circulating splash. **Ignition** in this particular illustration is the Atwater-Kent distributor and timer operated from cam shaft. (Mfgrs. Lycoming Fndry. & Mach. Co., Williamsport, Pa.)

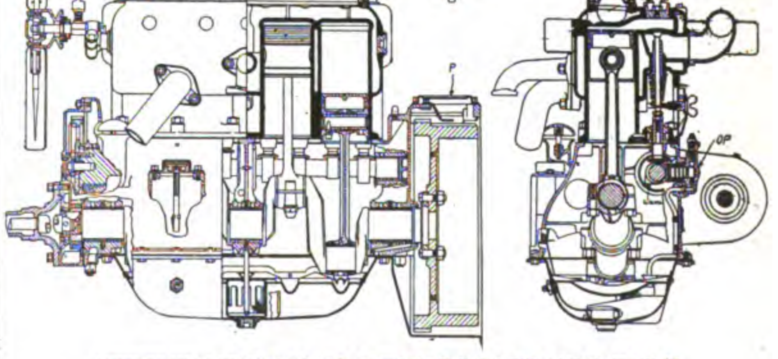
The Continental Engine is probably the most extensively used engine on different automobiles. By referring to the specifications of leading cars the name of cars using this engine will be given.

In addition to the information given on the illustrations, other information is given on this engine elsewhere—see index.





Above—The longitudinal section through a typical detachable head, Continental Six. The valve operation and method of adjustment are plainly indicated. Left—End section through Continental passenger car engine showing arrangement of moon-shaped throws on the crankshaft for balancing purposes. The oil pump is accessibly located and its operation is easily adjusted. This motor has a detachable head



Longitudinal and transverse sections through a four-cylinder Continental motor which can be used for trucks. Cylinders are in a block but the crankcase and oil pan are separate. The oil pump is operated off the camshaft and is located where it is easily cleaned and adjusted

CHART NO. 30-A—Examples of Modern Engines showing a cross sectional view. See Specificatio of Leading Cars for Specifications of Engines and Users.

INSTRUCTION No. 8.

*ENGINE PARTS: Stationary Parts. Moving Parts. Purpose, Principle and Location of Parts.

The stationary parts are: crank case, upper and lower half, bearings, cylinders, exhaust and inlet ports, valve caps, compression or relief cocks, water cooling pipes, carburetion and part of the ignition systems, exhaust and inlet manifolds.

The moving parts are: crank shaft, connecting rods, pistons, piston rings, piston pin or wrist pin, cams, cam shaft, timing gears, crank shaft gear, valves, valve plunger or tappet or lifter.

Crank Case.

The cylinder is attached at its open end to the crank case, which forms a box around the crank shaft.

The crank case is of irregular shape, so that while there is plenty of room for the cranks and connecting rods to operate, there is little waste space. It contains the crank shaft bearings, and forms the bed-plate or foundation, for the engine.

It is often made in two parts, an upper part bolted to the cylinder and containing the crank shaft bearings, and a lower part enclosing the crank shaft and which is called the "oil pan."**

As the lower crank shaft case is intended to contain lubricating oil, it is tight so that there may be no leakage. Usually the lower part of crank case can be removed for adjustment of bearings.

The crank case is usually made of aluminum alloy, or if in two pieces, the upper may be made of bronze, and the lower of aluminum and sometimes cast iron.

The crank case is used to support various parts of the mechanism, like the pump, magneto, etc. For an illustration of a crank case, see chart 31, fig. A, and chart 32, figs. E and F.

The arms for supporting the crank case on the chassis are sometimes made short to bolt to a sub-frame (22), as shown in chart 5, while other manufacturers make longer arms to extend and bolt to the main frame (21).

A "**three point suspension**" is where the power plant is suspended in frame at three points of contact.

A "**unit power plant**" is where engine clutch and transmission are in one unit as in fig. 6, chart 30 and page 44.

*Engine Bearings.

Engine crank shaft bearings are known as **main bearings**. Most of the manufacturers make four cylinder engines with **three main** bearings **for the** crank shaft, while others have as many as five.

On six cylinder crank shafts there are as many as seven bearings, the majority using three. See chart 36 and 55.

If the six cylinders are cast "**single**" which is unusual, usually 7 bearings; 2 ends and 5 inside are used. If cylinders are cast in "pairs" usually

---

*For repairs on engines, see "repairing instruction."

The S. A. E. designate two types of crank cases; the "split type" where the lower part is separate and contains no bearings. The lower part is then called the "oil pan." The "barrel type**" is when the lower part is permanently attached and has a hand hole plate for reaching the bearings, and crank shaft is removed from end of crank case with the removal of crank case head.

3 bearings; 2 ends and 1 inside. If cylinders are cast "in block," usually 3 bearings; 2 ends and 1 inside center (small engines). If ball bearings are used, then there are usually 3 bearings.

The bearings of a crank shaft are usually in two parts and made of bronze or *white metal babbit, or other metal that does not wear rapidly. These bearings are split lengthways into two parts, one part being supported by the engine base (called the bearing journal—fig. 1, chart 35), so that the shaft lies in it, and the other part covers the shaft at the same point, and is held in place by means of cap screws, (see fig. 3, chart 34).

When one of the main bearings becomes worn the lower cap is removed and a shim is taken out so it can be drawn tighter to the shaft. If it is burned or cut then a new lining of brass or babbit called a "bushing" must be put in or it can be dressed by scraping.

These **shims** are plates of thin metal placed in both main and connecting rod bearings (see fig. 2, chart 34), which are fitted in between the cap and upper part of bearing, so that by removing a shim or two they can be drawn closer together when loose.

A bushing is that part of a plain bearing that the shaft comes in contact with. They are usually made of babbit, phosphor bronze or white metal. The phosphor bronze are very hard and last a long time, but are somewhat liable to "sieze" if run without oil.

A white metal bushing consists of a layer of white metal, run, (when in a molten state), into a channel in the bearing. It then hardens and is scraped and polished. White metal has the virtue that if ill treated it does not seize and do much damage, but if run for a long time a knock would result.

Probably the first bearings to require renewal are those of the connecting rod. See page 641.

Connecting Rod Bearings.

The big end of the connecting rod is attached to the crank pin, and a bushing of bronze or white metal or other metal (with a melting point lower than that of cast iron) in the form of a shell surrounding the crank pin is secured in it. (Chart 34, fig. 1.)

The bushing is split lengthways into two halves, like the bearing of the crank shaft, one part being set in the connecting rod and the other being held in place by the **connecting rod cap.**

The small or upper end of the connecting rod contains a solid bushing that forms the **wrist or piston pin bearing.** (Fig. 1, chart 34.)

Because of the small space in the piston, it is not possible to have this bushing split and held in place by a cap. The bushing is therefore set in the connecting rod, and the wrist or piston pin pushed through it. The wear of the wrist pin bearing is slight, and if it should wear loose, a new bronze bushing is driven into the connecting rod.

The wrist or piston pin is passed through the piston, and secured so that it cannot move. (See fig. 4, chart 34.) It is usually case hardened.

On the Ford, fig 5, the wrist or piston pin moves with the motion of the connecting rod. The small end of connecting rod being clamped to it. The wrist pin moves in bronze bushings fitted in the piston.

Through the connecting rod, the piston transmits the pressure of the explosions to the crank shaft and fly wheel In order that it may withstand the heavy shocks of the explosions, the connecting rod must have great strength.

It is made of drop forged carbon steel, heat treated and in rare instances bronze. A straight I-beam type is used almost universally.

---

*See index for "white metal bushings." Connecting rods for high speed engines must be made light as possible, hence bronze being heavier is seldom used.

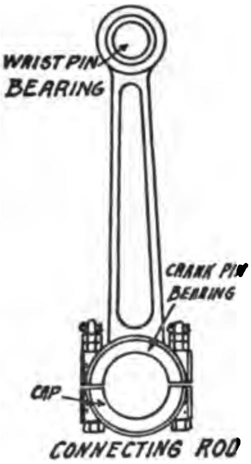


Fig. 1.—A connecting rod showing wrist pin bearing and crank pin bearing and cap.

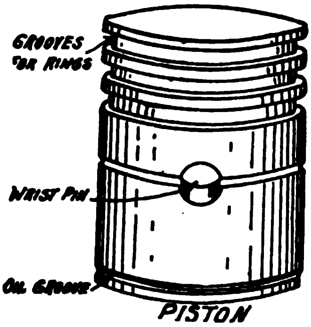


Fig. 6.—A trunk type of piston.

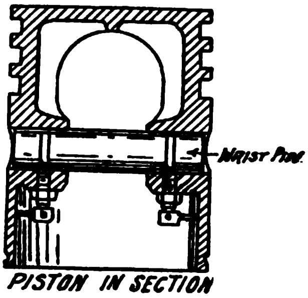


Fig. 4.—Sectional view of piston. Note wrist pin is stationary.

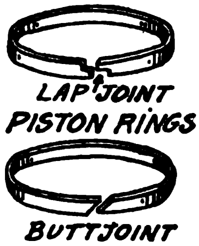


Fig. 8.—Two types of piston ring joints.

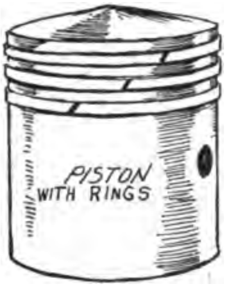


Fig. 9.—In order to prevent compression passing through joints of rings; they are placed as illustrated. Three rings is the usual number to a piston.

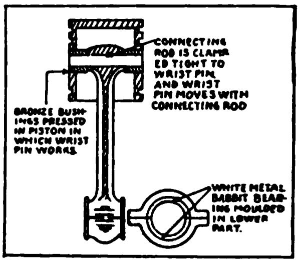

CONNECTING ROD IS CLAMPED TIGHT TO WRIST PIN AND WRIST PIN MOVES WITH CONNECTING ROD
BRONZE BUSHINGS PRESSED IN PISTON IN WHICH WRIST PIN WORKS
WHITE METAL BABBIT BEARING MOULDED IN LOWER PART.

Fig. 5.—Note in this type (Ford) the wrist pin moves with the upper end of connecting rod.

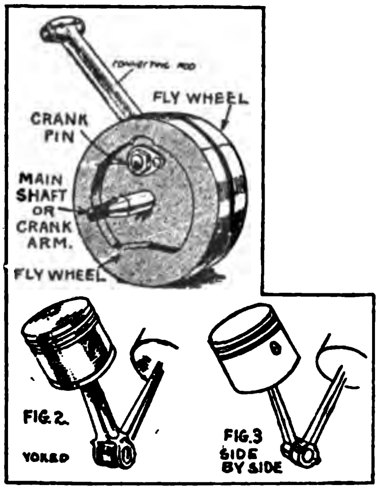


Fig. 7.—Upper illustration shows a connecting rod, crank pin and crank arm on a single cylinder motorcycle or cycle car engine. Note crank pin is between the two fly wheels which are placed in the crank case. Lower illustration explains the method of connecting two connecting rods to one crank pin on a "V" type engine.

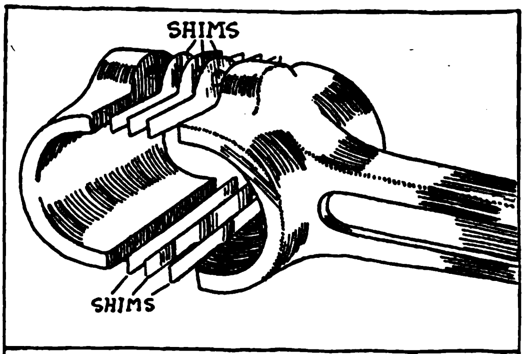


Fig. 2—Connecting-rod bearing end with cap removed to show shims

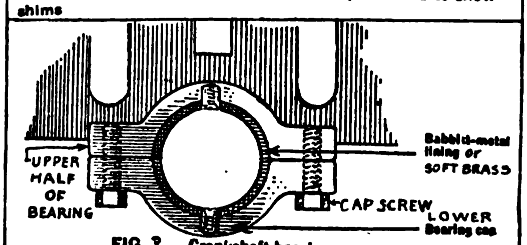


FIG. 3 —Crankshaft bearing

Fig. 2.—Illustrating how shims or liners are placed between lower connecting rod cap and upper part. When worn a liner can be removed. This permits the cap to be drawn closer to crank pin.

Fig. 3.—Showing how one of the main crank shaft bearings is lined with white metal babbit or bronze. Liners or shims are also used.

CHART NO. 34—Engine Parts; bearings, connecting rod, piston, piston rings.

Note—S. A. E. have discontinued the use of word wrist pin for piston pin which of course is more applicable. Chart 31 on page 62.

Connecting rod on a crank shaft of a "V" type engine can be placed either "yoked" or "side by side" as shown in fig. 7, chart 34. When they are yoked, the cylinders would be "in line"; if side by side the cylinders would be "staggered" or slightly out of line. See fig. 5, chart 36 of connecting rods on an eight cylinder engine.

*Pistons.

The piston of a gasoline engine is called a trunk piston, to distinguish it from the **disc piston** of a steam engine. (See chart 34, fig. 6.)

A trunk piston is longer than its diameter, and is hollow, with one closed end. The closed end is toward the combustion space, and it is against the closed end that the force of the explosion acts.

The piston pin passes through the piston, usually about the middle or a little nearer the top (dependant on the stroke.)

The open end of the piston permits the connecting rod to swing from side to side.

*The piston does not fit the cylinder tightly, for a tight fit would cause friction and wear. This space is called **piston clearance.** (see index.) The piston is usually slightly smaller at the top than bottom because the heat is more intense at top and expansion must be allowed for.

The pressure from the explosion is prevented from escaping between the piston and the cylinder wall by **piston rings.**

The piston rings fit in the groove around the upper end of the piston, and there may be from two to five of them, usually three. The rings fit the groove snugly, but not so tight that they may not move freely.

They are cut crossways, so that they may be sprung open. When closed, so that ends touch, the rings are a trifle smaller than diameter of cylinder.

When sprung open, they are larger than the diameter, or bore of the cylinder. They are so made that they always stand a little open.

The rings are slipped into the grooves by springing them open, and sliding them over the piston.

When a piston is to be placed in a cylinder, the rings are drawn together (see repair subject), so that they will slide in easily. The piston with its rings fits the cylinder snugly, and the elasticity of the rings keeps them pressed against the cylinder wall, **making a fit that keeps the pressure from escaping.**

None of the pressure of the explosion being able to escape, it is all exerted against the closed end of the piston, or **piston head.**

The rings must be placed on the piston so that the ends are not one over the other, for if they were in line the pressure might escape through them.

The rings are prevented from moving around the piston by **pins** placed between the ends. (Not on all pistons.) The only motion they have is the spring in and out.

The ends of the rings are beveled, or made with a joint that is shaped so that it is tight whether the rings are closed or open to the size of cylinder.

*For piston ring fitting, etc., see "repair instruction." **Aluminum alloy pistons** are now being used to a certain extent instead of cast iron for the following reasons: They are about one-third lighter. The inertia of the reciprocating piston is reduced considerably. This cuts down side pressure or thrust on the walls of the cylinders. This reduces friction and the consumption of lubricating oil. The great heat conductivity of aluminum alloy lessens the carbon deposit on the piston head and the deposit is more easily removed. In case of extreme heat if the piston seizes or buckles the cylinder is not damaged with aluminum pistons. First, there was a little trouble from wear on the skirt; it was difficult to get a close enough fit to insure absence of slap without abrasion. The trouble was overcome by one concern, the Franklin, by turning a shallow, square groove of screw thread form from the bottom of the skirt to just beneath the lower ring. This holds oil securely and allows a smaller clearance than is possible with a plain piston. Also see page 645 and 651, 637, 792.

*Pistons and connecting rods must be made lighter for high speed work. Where cast iron is used, which is general, the piston is made lighter by making the skirts thinner and piston pin boss, lighter. On small high speed engines the piston skirt is drilled all over with large holes for lightness.

*The usual clearance between a piston and the cylinder wall is explained in repair subject. See index for "pistons size of." The maximum clearance is at the upper part, for here the expansion is greatest owing to the heat of the explosion.

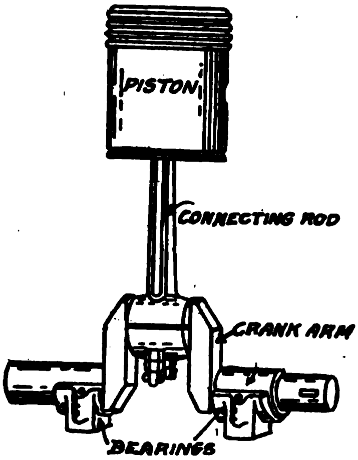


Fig. 1 — A single throw crank shaft. Crank set at 360 degrees.

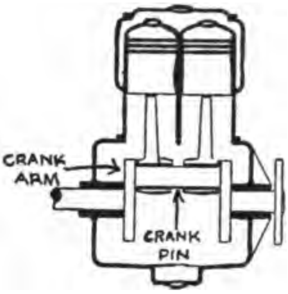


Fig. 2—A two cylinder vertical engine with a 360 degree crank shaft; both connecting rods on one crank pin.

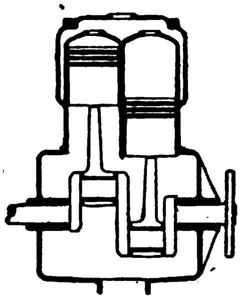


Fig. 3—A two throw crank shaft for a two cylinder vertical engine, crank set 180 degrees.

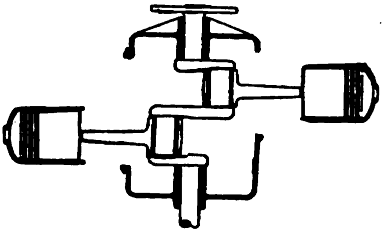


Fig. 4—A two cylinder opposed type of engine with crank shaft set 180 degrees. Cylinders are also 180 degrees apart.

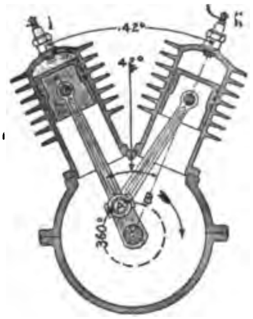


Fig 7—A two cylinder twin type of engine used on motorcycles and light cars. Note the 360 degree crank. Cylinders at 42° angle.

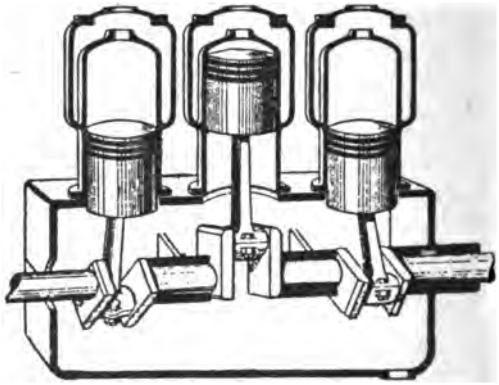


Fig. 5—A three cylinder vertical type of engine with cranks set at 120 degrees. Note No. 2 piston is up. No. 3 (right) would be 120 degrees or one-third of a revolution; No. 1 would be 120 degrees or one-third revolution from No. 3, or two-thirds from No. 2.

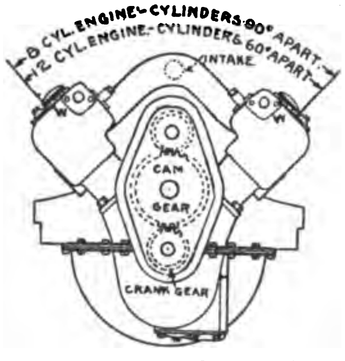

8 CYL. ENGINE-CYLINDERS 90° APART
12 CYL. ENGINE-CYLINDERS 60° APART
INTAKE
CAM
GEAR
CRANK GEAR

Fig. 8—A "V" type eight cylinder engine. A regular 180 degree four cylinder type of crank shaft is used with two connecting rods on one crank pin.

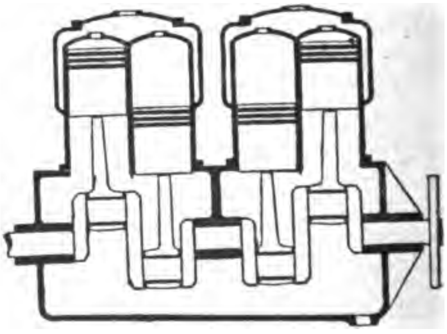


Fig. 6—A four cylinder vertical engine with crank shaft set 180 degrees. Note 1 and 4, and 2 and 3 pistons are always in line.

CHART NO. 35—Crank Shafts.

Two of the usual types of piston rings are shown in chart 34, fig. 8. *piston rings are made of cast iron.

There are many improved types of piston rings which the manufacturers claim will not leak; usually three rings are placed on a piston. The Falls Co. has changed to two rings and claim that for high speed work two is sufficient whereas, for slow speed work three rings are necessary.

†The Crank Shaft.

The crank shaft throw changes the reciprocating motion of the piston to the rotary motion necessary to turn the wheels. It rests in bearings that hold it in a fixed position, but permit it to revolve.

The crank pin must be rigidly attached to the crank shaft, and to secure this rigidity they are usually made in one piece, solid as in fig. 1, chart 35, and is made of chrome nickel steel.

The crank projects from the crank shaft, and when the shaft revolves, the crank makes circles around it. A crank is one of the most common mechanical devices. The crank pin is that part to which the connecting rod fits and is also called the "**throw**" of the crank.

A windlass is turned with a crank; a bucket or chain pump is operated with a crank; the pedals of a bicycle form cranks.

In a bicycle, the crank arms are attached at their inner end to the crank shaft, and to their outer ends the pedals are attached.

When riding a bicycle, the feet press on the pedals at the ends of the crank arms, and make the crank shaft revolve. The feet describe circles around the crank shaft. Each crank arm and pedal form a crank and there is only one arm to a crank.

In a gasoline engine, two arms are necessary for the reason that the cranks are not at the ends of the shaft, there are therefore **two arms** to each crank. (Fig. 1, chart 35.)

The outer ends of the crank arms are connected by the **crank pin.** The crank pin corresponds to the pedal of a bicycle. A gasoline engine has as many cranks as it has cylinders* (see foot note).

Meaning of Degrees as Used with Crank Shaft.

The position of a crank on a crank shaft in relation to other cranks on the same shaft is expressed in **degrees** of a circle.

If a crank shaft has **two cranks projecting in opposite directions,** as in fig. 3, 4 and 6, chart 35, it is called a **180 degree** crank shaft.

If the **cranks project from the same side of the shaft,** as in figs. 1 and 2 so that the crank pins are in line it is called **360 degrees** crank shaft.

In such a case, as shown in fig. 2, chart 35, instead of having two pairs of crank arms with a crank pin to each pair, the crank pin may be made long enough to hold both connecting rods, and has only one pair of crank arms. Both connecting rods drive one crank. This type of engine, however is not used on account of its uneven firing (see chart 53, page 116, for firing orders). Engines with crank shafts as shown in figs. 3 and 4 would fire more regularly.

The engine in fig. 4 is called the opposed type of engine. It was formerly used to a great extent on small cars and is still used to some extent on trucks and tractors for heavy work. The cylinders are placed **180 degrees apart** (see fig. 1, chart 38); the crank shaft is also 180 degrees.

The four cylinder engine, fig. 6, chart 35, employs a **180 degrees crank shaft.** Note "throws" of crank on cylinder 1 and 2 are 180 degrees apart, and 3 and 4 are 180 degrees apart.

---

†See chart 55 for six cylinder crank shaft explanation.

*Fig. 2 shows a two cylinder engine with one crank. This type, however is obsolete.

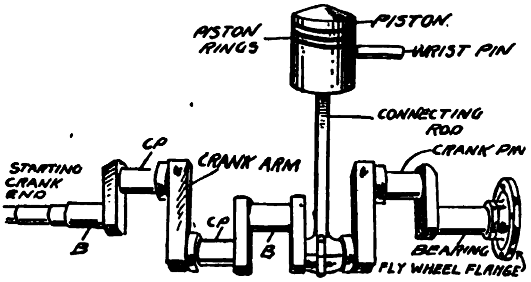


Fig. 1. A solid type of crank shaft—three bearing type, four cylinder.

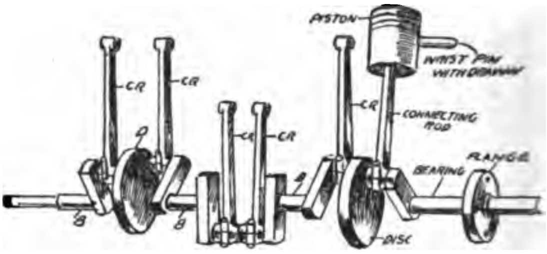


Fig. 2. A built up type of crank shaft (seldom used). The above is a six cylinder crank, with four bearings.

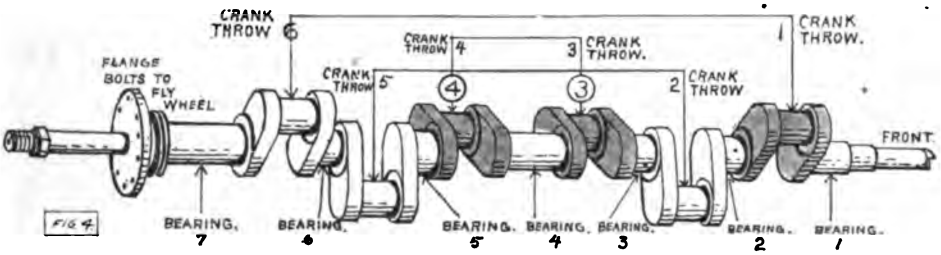


Fig. 4. A solid crank shaft, with seven bearings. Six cylinder.

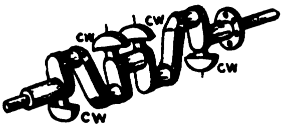


Fig. 12. Typical counterbalanced four-throw crankshaft. This method of balancing is used on the Stearns-Knight, Cole and Oakland engines.

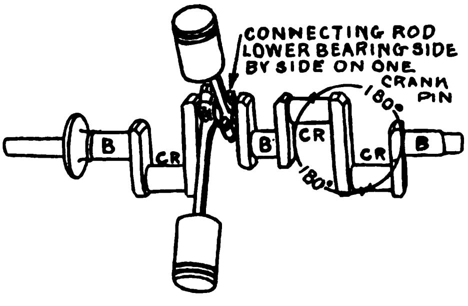


Fig. 5. A regular four cylinder type, 180° crank shaft is used on the 8 cylinder "V" type of engine. Two connecting rods are placed on one crank pin; either side by side, or yoked (see fig. 7, chart 34).

If side by side the two cylinders would not be in line but "staggered." If connecting rods were "yoked" then the cylinders would be in line.

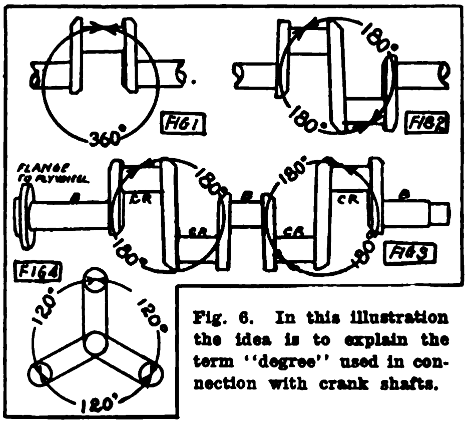


Fig. 6. In this illustration the idea is to explain the term "degree" used in connection with crank shafts.

Any perfect circle is 360°. If the circle is divided into quarters, each quarter would be 90°; half of the circle 180°; a third 120°.

Fig. 1. Note one crank pin—hence 360° crank.

Fig. 2; from center of one crank pin to center of other is half a circle or 180°.

Fig. 3; here we have two pairs of crank pins as shown in fig. 2, but on one crank; also 180°.

Fig. 4; end view of a three or six cylinder crank shaft. Note crank arms are one-third apart or 120°.

CHART NO. 36—Crank Shaft Construction.

Therefore, pistons on cylinders 1 and 4 are always up or down **together,** and 2 and 3 are up or down **together** or in line.

The eight cylinder "V" type engine would in reality be nothing more than two four cylinder engines with cylinders set "V" shape. The angle of cylinders usually being **90 degrees** or one-half of the 180 degrees of the crank shaft. The same four cylinder 180 degrees crank shaft is employed. **There are two connecting rods to each throw of the crank,** which can be placed "**side by side,**" fig. 5, page 78 or "**yoked,**" fig. 7, page 76.

If connecting rods were side by side, then it would be necessary to "**stagger**" cylinders by setting them out of line with each other.

A three cylinder engine must have a crank shaft with the three crank pins placed in three positions, or one-third of a revolution apart; this would be placing them **120 degrees** apart, see fig. 5, chart 35, and fig. 5, chart 52.

A six cylinder engine would have a crank shaft with six crank pins or crank "throws" placed in thirds, or **120 degrees apart.** There would be three pairs in line—see fig. 4, page 78 and figs. 4 and 5, page 122.

***A twelve or twin six cylinder "V" type engine would use the same type of six cylinder crank shaft,** but with two connecting rods to each crank pin. The cylinders would be placed **†60 degrees** apart or one-half of the 120 degree crank shaft. The cylinders would be "staggered" if connecting rods were placed "side by side" per fig. 5, page 78.

The twin cylinder "V" type of engine used on a cycle car and motorcycle would use a **360 degree** crank or one crank pin, with connecting rods yoked.

Cylinders on this type of engine are usually placed at an angle from **42** to **45** degrees apart.

Construction of Crank Shafts.

There are two kinds of crank shafts, one known as the "solid crank shaft" and the other as the "built up crank shaft." (See figs. 1 and 2, chart 36.)

The solid is by far the most used. It is made from one piece of steel, which is forged to shape and then turned up in a lathe, the workmanship in many cases being accurate to a ten-thousandth part of an inch.

The built up crank shaft has each of its parts made separately and then fixed strongly together and quite often fitted with ball bearings.

An advantage of the built up crank is that the crank shaft bearings could be fitted with ball bearings. However, built up shafts of this kind are not usual, and in the case of powerful engines, only the strongest solid crank shafts are ever used.

The counter balanced crank shaft with counterweights (CW) electrically welded to the crank shaft and an integral part of the crank shaft, as illustrated in chart 36 is becoming popular. It permits high speeds to be obtained without detrimental vibration, and relieves the tendency to "whipping" of the crank shaft and "slapping" of the pistons. (see fig. 12, chart 36.)

Cylinders—see chart 37.

The cylinder of a gasoline engine is made of cast iron or 20 per cent semi-steel, and the water jackets are generally cast in one piece with it.

In some designs, notably the old Pope-Toledo and 1914 Cadillac, the water jackets were formed by surrounding the upper part of the cylinder with sheet copper. See fig. 2, chart 37.

The cylinders of an engine with more than one cylinder, are either **cast singly,** or **in pairs**; that is, two cylinders with their water jackets are made in one piece.

---

*The twelve cylinder engine was formerly referred to as used on motor boats, where 12 cylinders were placed in a row. The "twin six" refers to cylinders of 6 to a side, placed "V" type. However, inasmuch as the 8 cylinder is referred to as an "eight," although it is also placed 4 cylinders "V" type, we will not adhere to this rule entirely.

†On some of the twelve cylinder airplane engines (see page 918), the cylinders are 45 degrees apart. The Liberty engine cylinders are 45 degrees, see page 934.

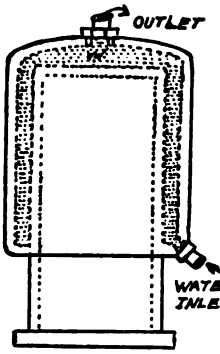


Fig. 1. A single cylinder with water jacket cast around it.

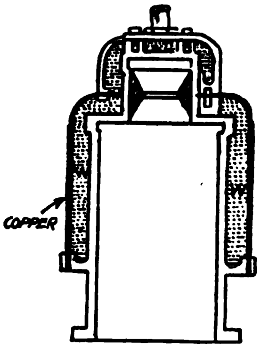


Fig. 2. A single cylinder with a copper water jacket placed around it.

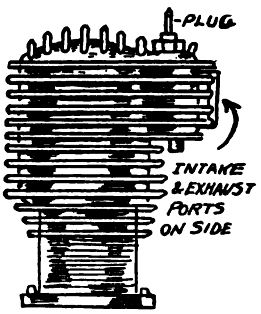


Fig. 3. Air cooled flange type single cylinder.

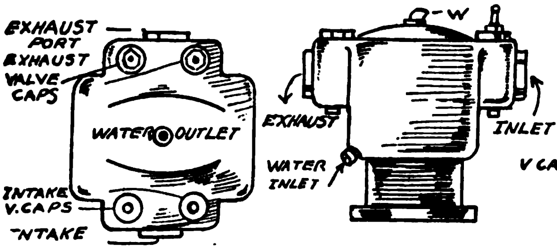


Fig. 4. **"T" type of cylinder.** Note inlet ports on one side and exhaust ports on other side. Called "T" type because it is T-shaped.

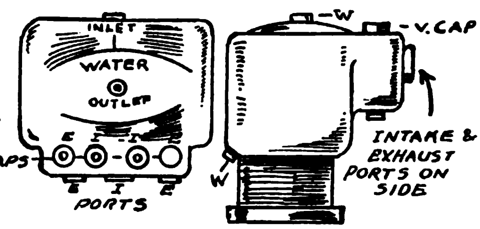


Fig. 5. "L" type of cylinder. All valves are on one side. Called "L" type because it is L-shaped.

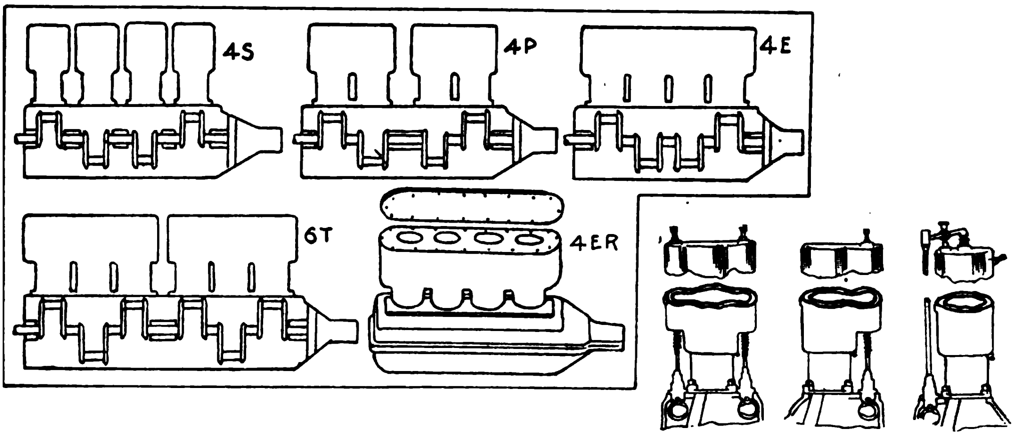


Fig. 6. METHODS OF CYLINDER CASTINGS—Cylinders cast "singly" is illustrated at (4S). The crank shaft is a 180° with five bearings.

Cylinders cast in "pairs" in fig. (4P). Crank shaft 180° with three bearings.

Cylinders cast "in block" fig. (4E), note a two bearing crank shaft. Seldom used, only on very small engines with short crank shaft.

A six cylinder engine, with cylinders in "triplets," (fig. 6T). Note the crank shaft appears to be 180° type, but is divided into thirds (see fig. 4, chart 36).

Cylinders in block with detachable cylinder head is illustrated in fig. 4ER).

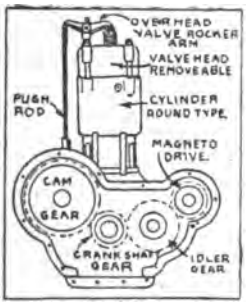


Fig. 7. Round or "I" head, with detachable head.

Fig. 7. Round type of cylinder. Valves overhead. The upper part with the valve in the head is detachable and is called "valve in the head" type of valve arrangement. This type of cylinder is also called "I" type.

ART NO. 37—Cylinder Types.

The portion of the cylinder in which the piston moves should be a true circle, and as smooth as possible. In the better grade of cars the cylinders walls are **ground** to a smooth finish so that there may be as little friction as possible. Any roughness of the walls will cause wear, which comes in the form of cuts and scratches lengthways, that permit the pressure to escape around the piston.

Cylinder heads may be cast **solid** or with **detachable** head, see fig. 9, page 90; also Ford engine, page 783 and insert No. 2. The detachable head is gaining in favor. It permits easy access to the valves, and for removing carbon, removing pistons and is good manufacturing practice because it makes grinding of cylinders easier.

Types of Cylinders.

Cylinders of engines are made in several different shapes.

†**The "T" head type** of cylinder is made so that the exhaust valves are on one side and the inlet valves are on the other side. Note the "T" shape in fig. 4, chart 37.

†**The "L" head type of cylinder** is made so that the exhaust and inlet valves are all on one side of the cylinder. Note the "L" shape in fig. 5, (if turned up side down).

†**The "I" head type of cylinder** is made so that the valves are placed in the top of head of cylinder—both valves on one side or opposite, fig 7.

The "F" head type of cylinder: inlet valve in the head, exhaust valve on side. See fig. 6, page 88.

When an engine has more than one cylinder, the cylinders can be cast **singly** or in **pairs**—and can be of either the T, L, round or I head type. (See figs. 4, 5 and 7.) Sometimes multiple cylinder engines use all cylinders cast singly (4s fig. 6). They can be of the T, L or I head type.

***Cylinders cast "en-bloc"** means that the four cylinders on a four cylinder engine, are all cast in one piece (see fig. 4E). They can also be of the T or L head construction.

Cylinders on the six cylinder engine (6T); can be cast in "triplets," singly, in pairs or in block. The "L" type is used on the most of the six cylinder engines. They are usually cast in pairs of three cylinders to a block.

Cylinders on an eight cylinder "V" type engine are usually cast "in block" and are placed 90 degrees apart, and on a twin six cylinder engine, 60 degrees apart. On a twin "V" cycle car or motorcycle engine, 42 to 45 degrees. (See chart 35.)

The offset cylinder with an offset crank shaft or offset cylinders, as you choose to say, is represented in fig. 5, chart 38. The line A, which passes through the center of the cylinder, is some distance to one side of the line B, which passes through the center of the crank shaft. Some of the advantages claimed for the offset crank shaft are less liability of a back kick, reduced wear on the bearing surface of the cylinder walls, connecting rods and crank shaft, less liability of the engine to be stalled, when the car is running slowly on a high gear, and other construction facilities. The cylinder set central over the crank shaft, as in fig. 4, is the type in general use. Cylinders can be placed horizontally, vertically or at an angle, (see chart 38).

Meaning of Bore and Stroke.

The stroke is the length or distance the piston travels up and down inside of cylinder.

The bore of a cylinder is its inside diameter.

---

*The word "en-bloc" is taken from the French. The S. A. E. now term this word as "in-block."

*See index for "advantages and disadvantages of the T, L and I head cylinders."

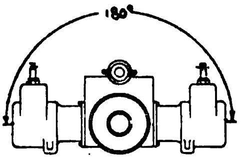


Fig. 1. Note cylinders are placed 180 degrees apart and are in a horizontal position.

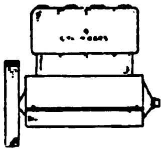


Fig. 2. Cylinders vertical-type; in general use.

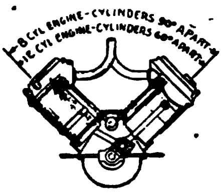

8 CYL ENGINE-CYLINDERS 90° APART
12 CYL ENGINE-CYLINDERS 60° APART

Fig. 3. Cylinders at an angle—called "V" type. Note a 180 degree crank is used on an eight "V" type, and cylinders are placed one-half of this, or 90 degrees apart.

The crank shaft on a 12 cylinder engine is a 120 degree crank, and cylinders are placed at an angle of 60 degrees apart.

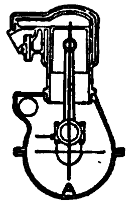


Fig. 4. Diagram of usual method of setting cylinders central, directly over crank. Note line (A)—both connecting rod and crank arm are in line.

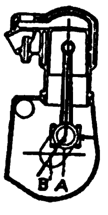


Fig. 5. The offset cylinder or Des Axe crank shaft setting. Cylinders may be L, T or round type. Note line (A)—connecting rod is in a perfect vertical position, but crank arm is at an angle. The cylinder being "offset" causes this.

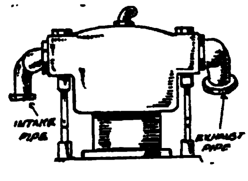
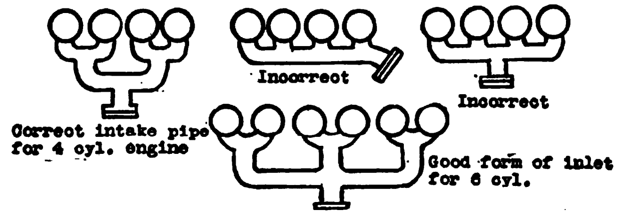
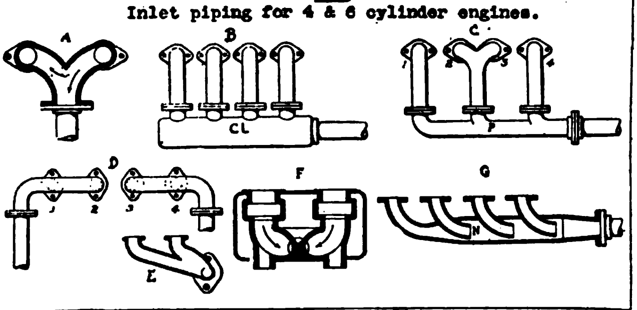


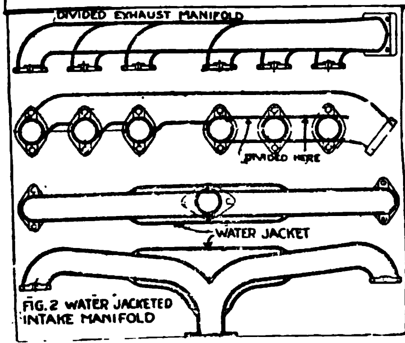
Fig. 6. "T" head type of cylinder with exhaust manifold on one side and intake manifold on the opposite side.

If cylinder was "L" type, the exhaust and inlet manifold would both be on one side or the valve side.


Incorrect
Incorrect
Correct intake pipe for 4 cyl. engine
Good form of inlet for 6 cyl.

Inlet piping for 4 & 6 cylinder engines.





Inlet and Exhaust Manifolds.

Exhaust manifold construction: A is a good method of exhaust outlet for a 2 or 4 cylinder vertical engine.

"B;" a simple manifold in which an individual pipe from each cylinder injects directly into the large collector chamber "CL." In this manifold the collector tube is made sufficiently large so that when the exhaust valve closes, the pressure in it is less than that in the cylinder at the valve, so that there is no danger of back pressure.

"C" shows an arrangement in which the pipes 2 and 3 for the middle chambers are formed in one, whereas they are separate for cylinders 1 and 4. This works satisfactorily in that cylinders 2 and 3 never explode consecutively, and the one pipe is capable of taking care of the exhaust of the two.

"D" is quite similar to that in "C," excepting in that there are individual pipes for cylinders 1 and 2, and 3 and 4. This is bad construction, in that 4 explodes immediately after 3, and 1 immediately after 2.

As the direction of exhaust leaving the cylinders is the same, it is very easy to make a manifold in which the exhaust pipe, instead of having a tendency to obstruct one another, assists the other cylinders to exhaust.

In engines which have their inlet and exhaust valves opposite, frequently all four of the exhaust valves are connected through one manifold with a single orifice. "F" is one example of an arrangement where it is possible to make the two passages unite. This is suitable for engines with cylinders cast in pairs. The defects of "A" and "D" can readily occur in this one; if makers were considering loss of power they would not use this one, but they only want to save space.

For the best design, illustration "G" offers a reasonable solution. In this illustration there is an individual pipe from each cylinder to the large collector. At the end, each individual pipe projects into the collector tube and curves in the direction of the exit for this collector tube.

The divided exhaust is used on several six cylinder engines with cylinders cast in two blocks of three cylinders to a block. This is claimed to prevent overlapping and refilling of the cylinders with burned gases.

The water jacketed inlet manifold is shown in the lower illustration. The water connection is with the pump circulating system, see also page 157.

CHART NO. 38—Cylinder Angles (also see page 134). Inlet and Exhaust Manifolds. Also see pages 164 and 157.

---

*modern type inlet manifold is jacketed to take either the hot exhaust gases or hot water, per pages 157 158, in order to heat the gas mixture before entering cylinder.

Square stroke; when the piston travel in a cylinder has the same length as the bore in diameter, then it is called a square stroke and bore.

†**Long stroke**: when the piston travel is much more than the bore diameter, then it is called a long stroke. For instance, a piston 4x4 inches is called "square stroke." A cylinder whose bore is, say, 4 inches and the stroke is 5½ inches, this would be called a "long stroke."

The valve chamber is that part surrounding the valve. **The valve port** is the opening for the intake or outlet of gas.

The combustion chamber is the inside upper portion of cylinder, above piston, when the piston is at the top of its stroke.

**Inlet Manifold and Pipe—see chart 38.

The inlet manifold is the part which connects to the inlet port openings in cylinders, from carburetor. If there is only one connection to cylinder, as on a single cylinder engine, then it is called an **inlet pipe.**

When the valves are all placed on one side of the engine, as in the "L" head type of cylinder, then the inlet and exhaust manifold are both on the same side of the cylinder.

When the inlet valves are on one side and the exhaust valves on the other side, as in a "T" head cylinder, then the inlet manifold is generally on one side and the exhaust manifold on the other side.

In order that there may be as little resistance as possible to the flow of the mixture, this manifold should be as straight as the position of the carburetor will permit. There should be no sharp angle bends, the bends being as flat and easy as possible and the distance from carburetor to inlet ports as short as possible to prevent condensation.

When more than one cylinder is supplied from one carburetor, the distance from the carburetor to each valve should be the same. The inside of the inlet manifold must be smooth and clear inside so that there is no obstruction offered to the flow of gas.

In those marked "incorrect" (chart 38), the distance from the carburetor to the inlet valves are not equal, and consequently the valves nearest the carburetor will get more of the mixture than those farther away.

In the arrangement marked "correct," the distances are equal, and consequently the valves get equal quantities of mixture, and the engine will run more evenly than if the cylinders received different amounts.

Exhaust Manifold Construction.

In chart 38 exaggerated and simplified illustrations are shown in order to give the reader an idea of the different methods.

Sharp bends in the exhaust pipe cause back pressure, and should be avoided. Dirt in the pipe or muffler has the same effect, and this should be guarded against.

Exhaust Pipe and Muffler.

The exhaust pipe leads from the exhaust manifold to the muffler. If engine is an eight or twelve "V" type, there are usually two exhaust pipes and two mufflers.

In order that the exhaust manifold may be cooled as rapidly as possible, the exhaust manifold and pipe, connecting the exhaust valve chamber to the muffler, is exposed to the air.

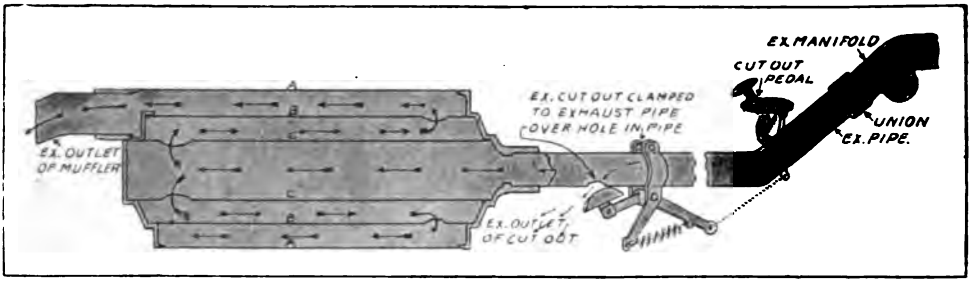
The connection from exhaust manifold to exhaust pipe is usually made with a flange connection with asbestos packing between.

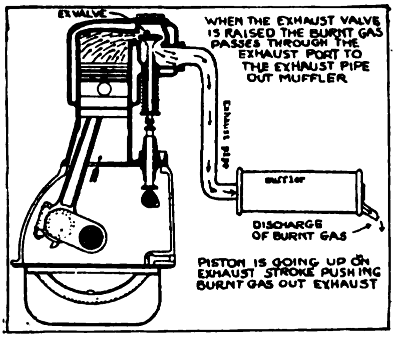
***The muffler and exhaust** pipe should be made so that there is as little **back pressure** as possible. Back pressure is caused by anything that prevents the free escape of the gas therefore sharp bends should be avoided, otherwise the incoming fresh mixture becomes mixed with that part of the burned gas left from the previous charge, and the power of the engine is cut down accordingly. The muffler is explained in chart 39.

---

†See page 531 for "advantages and disadvantages of long and short stroke."

**The modern inlet manifold is water jacketed or gas heated as per pages 157 and 164.




EX. VALVE
WHEN THE EXHAUST VALVE IS RAISED THE BURNT GAS PASSES THROUGH THE EXHAUST PORT TO THE EXHAUST PIPE OUT MUFFLER
Exhaust Pipe
muffler
DISCHARGE OF BURNT GAS
PISTON IS GOING UP ON EXHAUST STROKE PUSHING BURNT GAS OUT EXHAUST

Muffler: If the exhaust valve opened directly into the air, the noise of the explosions would be like the firing of a gun.

This is because the Pressure in the Cylinder is much higher than the Pressure of the air, and a sudden change from one to the other would produce a loud report.

The more sudden the change, and the greater the difference in the pressure, the sharper would be the noise.

The Pressure must be reduced before the Gas Escapes into the air, in order to reduce the noise.

The Exhaust is therefore connected, by means of the **Exhaust Pipe,** to the **Muffler** or **Silencer.**. (See Chart5, Figs. 47-48.)

The Muffler is placed in the end of the Exhaust Pipe in order to silence the noise of the exhaust. It is usually made of sheet iron and piping as shown in section. Sometimes the mufflers are not sufficiently large to expel the burnt gas as rapidly as it should, therefore heating is the result. **Mufflers** clog up with soot and also cause heating.

The Exhaust Gases passes first into the tube or chamber (C) as per arrow marks; then through openings into chamber (B), then through openings in opposite end into (A) then into the open air.

The Exhaust Cut Out is placed between the engine and muffler. When opened by the foot pedal movement, the exhaust gases pass out into the open air without passing through muffler.

The Object is to reduce Back Pressure. Sometimes mufflers are not designed properly and in order to silence the exhaust noise, the passage of gas is not rapid enough. There is a tendency for the gases to work back against the outcoming exhaust. Therefore, by opening the cut out the gases pass out quicker, relieving the back pressure. It is used when climbing steep hills or in racing.

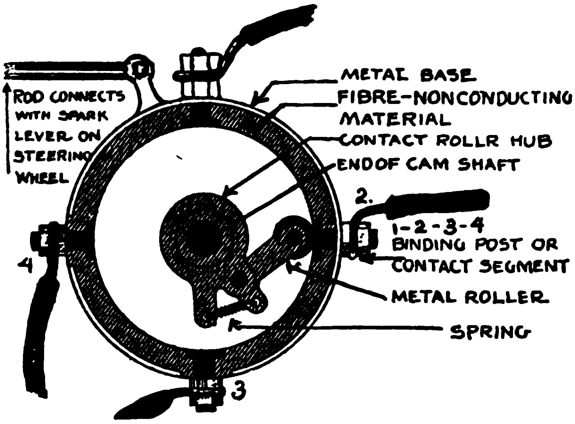

ROD CONNECTS WITH SPARK LEVER ON STEERING WHEEL
METAL BASE
FIBRE-NONCONDUCTING MATERIAL
CONTACT ROLLR HUB
END OF CAM SHAFT
2.
1-2-3-4 BINDING POST OR CONTACT SEGMENT
METAL ROLLER
SPRING
4
3

Fig. 5.—The Spark Timing Device is so named because it "times" the spark at the right time. In other words the roller makes contact with one of the segments (1-2-3 or4 in a four cylinder engine). Each segment controls one of the spark plugs (through a coil) in one of the four cylinders. When the right cylinder is ready to fire the timer makes contact and starts the coil which sparks the plug.. This device is called a commutator, and is used only with a coil system of ignition.

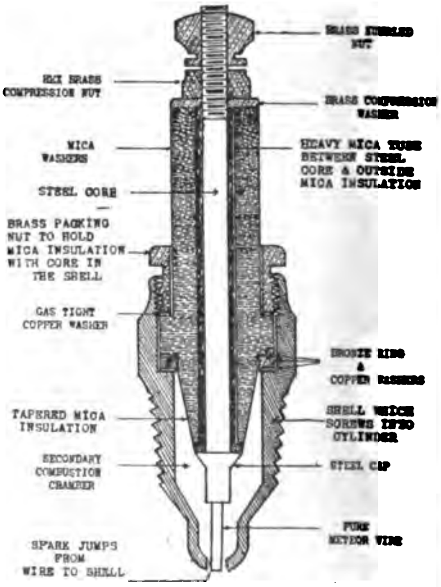
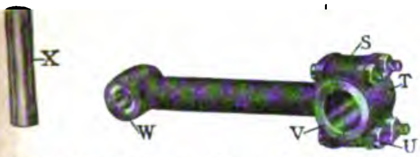

BRASS KNURLED NUT
HEX BRASS COMPRESSION NUT
BRASS COMPRESSION WASHER
MICA WASHERS
HEAVY MICA TUBE BETWEEN STEEL CORE & OUTSIDE MICA INSULATION
STEEL CORE
BRASS PACKING NUT TO HOLD MICA INSULATION WITH CORE IN THE SHELL
GAS TIGHT COPPER WASHER
BRONZE RING & COPPER WASHERS
TAPERED MICA INSULATION
SHELL WHICH SCREWS INTO CYLINDER
SECONDARY COMBUSTION CHAMBER
STEEL CAP
PURE METEOR WIRE
SPARK JUMPS FROM WIRE TO SHELL

Fig. 6.—The Spark Plug is screwed into the head of the cylinder. A wire is connected from this plug to a spark coil. The spark coil is set to work at the right time by a timer or commutator. When the coil or magneto is operating, an electric spark occurs at point of the plug, inside the cylinder, and ignites the compressed gas.

HART NO. 39—Muffler, Exhaust Out Out, Timer or Commutator, Spark Plug.

ee page 86 for Chart 40. *See page 622, "Cleaning a Muffler."



Connecting rod. S—Connecting rod shims, or ers, T—Connecting rod bearing cap, U—nnecting rod bearing cap nuts, V—Connecting d bearing, W—Piston pin bushing, X—Piston wrist pin.

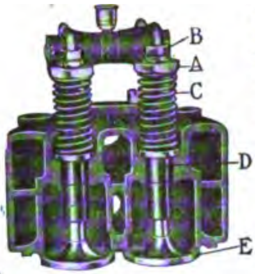
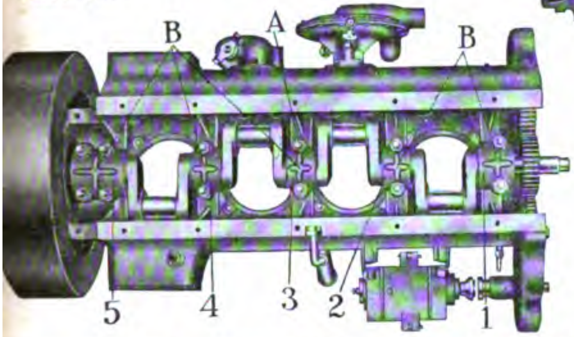
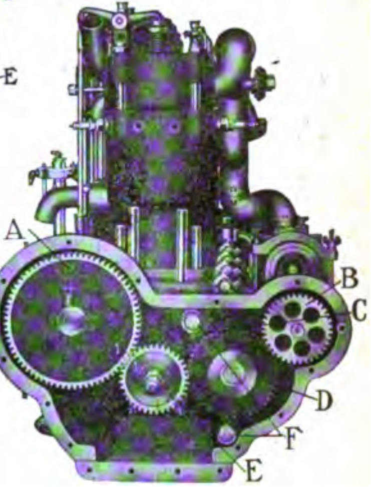


Fig. 2: Cylinder head is detachable with valves. Cylinders are separate, therefore a head is necessary for each cylinder. **If cylinders** were "en-bloc" (per page 80-4ER), then there would be but one head. A—Valve spring cap nut, B—Valve spring cap lock nut. C—Valve spring. D—Valve stem guide. E—Valve.



Crank case of engine bottom side up, showing main bearings nd crank shaft in its bearing. There are five main bearings this particular engine, usual number is three. 1, 2, 3, 4, 5 —**Crank shaft bearings. A—Bearing cap** nuts. B—Bearing caps.

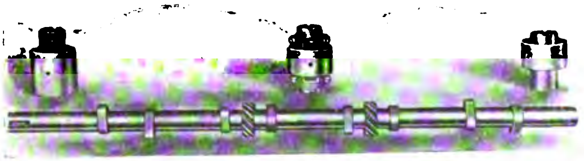


End view of engine below—showing the gears. Gear E measures 4 inches, gear A measures 8 inches. A—is the cam shaft gear (all valves on one side), and overhead, mechanically operated.

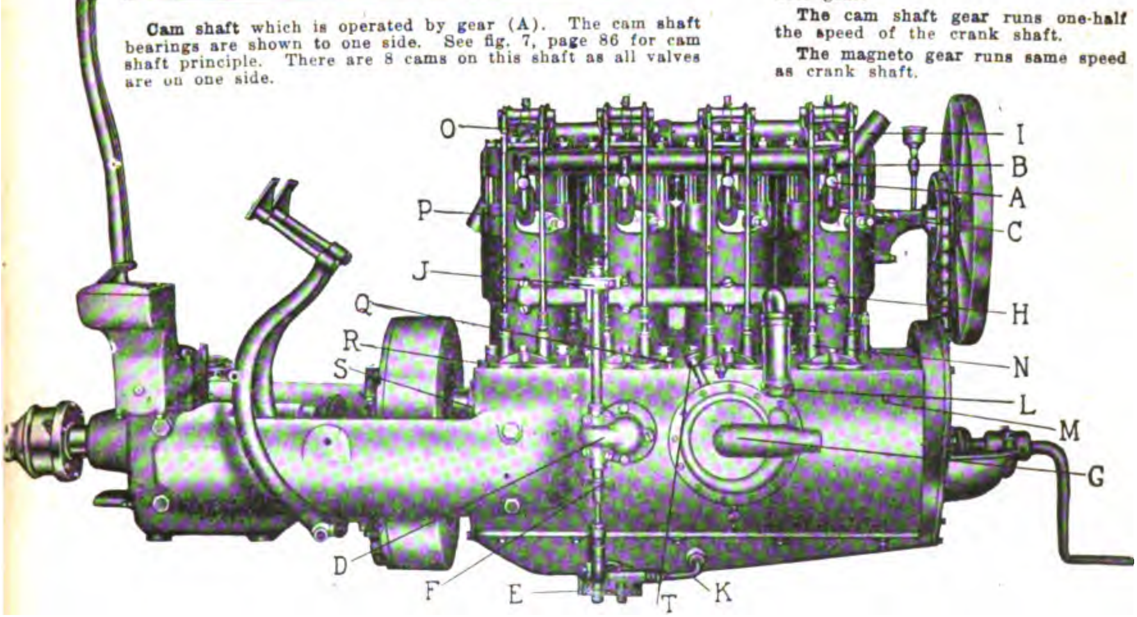
E—Drive gear on crank shaft. D—Idler gear between drive gear and gear operating the magneto. B—Magneto gear.

The cam shaft **gear runs** one-half the speed of the crank shaft.

The magneto gear runs same speed as crank shaft.



Cam shaft which is operated by gear (A). The cam shaft bearings are shown to one side. See fig. 7, page 86 for cam shaft principle. There are 8 cams on this shaft as all valves are on one side.



Valve side. Exhaust and inlet valves are both mechanically operated and are overhead type. A system of overhead rocker arms for both inlet and exhaust. See page 88 for explanation of various types of valves.

A—water manifold clamp bolt, B—water manifold clamp, C—outside water connection, D—oil pump and ignition timing gears, E—oil pump, F—oil pump spring catch, G—water pump, H—intake water manifold, I—return water manifold, J—ignition timer, K—oil pipe, L—hose clamp, M—front cam shaft bearing screw, N—valve lifter, O—push rod adjustment, P—valve push rod, Q—center cam shaft bearing screw, R—rear cam shaft bearing screw, S—rear cam shaft bearing cap. T—water pump grease cup.

CHART NO. 41—Study of a 4 Cylinder Unit Power Plant: Valves; overhead; **Cylinder head,** detachable **with valves. Valves are ground in head; Cylinders; "I" or round head type cast singly, modern practice is to cast in pairs for 4 cylinders, and in pairs of three for 6 cylinder engines. Note the difference in the "valve in head" and other "overhead valve" systems in chart 42, page 90.**

(Chart 40 on page 86—by error.)

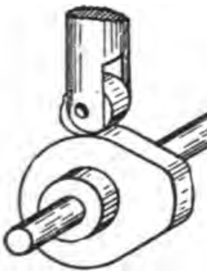


Fig. 1.—Showing the nose of cam.

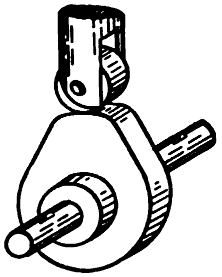


Fig. 2.—Nose of cam raising valve plunger which raises valve.

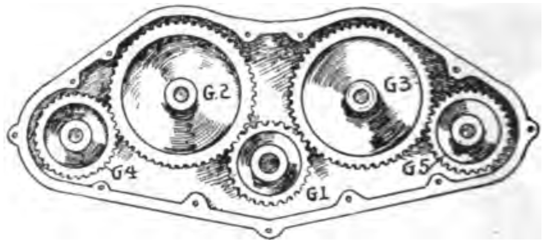


Fig. 3.—End view of the cam gears and drive gear. The two cam gears are called "half time" gears, because they revolve just one half the time or revolutions as the drive gear. G1—drive gear, on crank shaft. G3, cam gear to drive inlet cams. G2, cam gear to drive exhaust cams. G4 and G5 are extra gears to drive magneto and generator. ("T" head engine.)

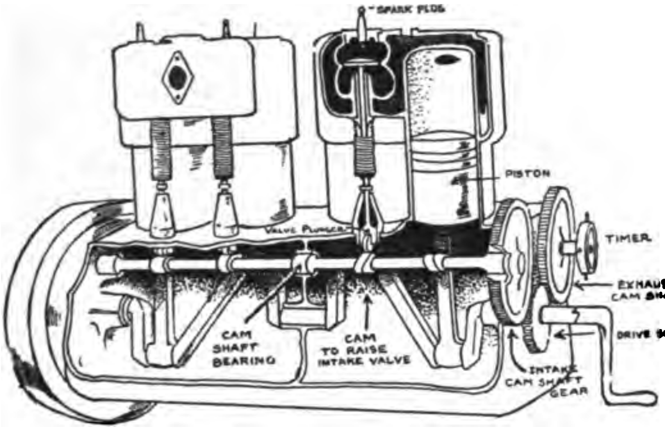


Fig. 7.—Illustrating how the cam shaft on a four cylinder engine is operated by timing gears. Also how the nose of cams raise the valves. There are two cam shafts placed opposite, therefore it would be a "T" head type.

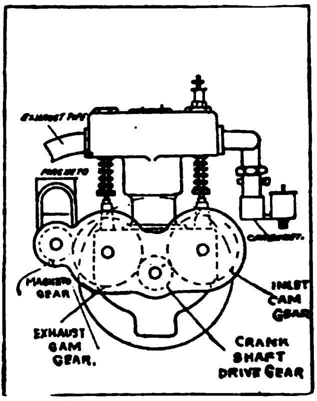


Fig. 4.—Showing method of driving the two cam shafts and magneto on a "T" head engine.

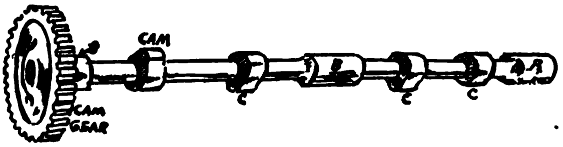


Fig. 8.—The cam shaft as used with a four cylinder T-head type cylinder. There are two shafts, an intake cam shaft and an exhaust cam shaft—one on each side of the cylinder as shown in fig. 4. There are four cams on each shaft.

The nose of the cams are placed at different positions so that the valves will be raised at a certain time. C—are the cams. B—are the bearings for the cam shaft.

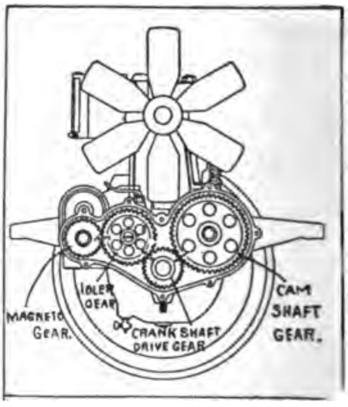


Fig. 5.—Method of driving the one cam shaft, and idler gear to drive magneto drive gear on an "L" head cylinder engine.

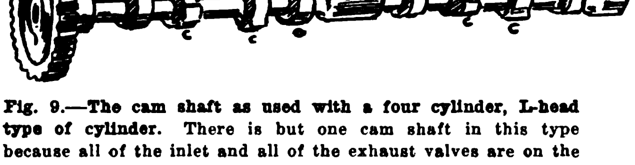


Fig. 9.—The cam shaft as used with a four cylinder, L-head type of cylinder. There is but one cam shaft in this type because all of the inlet and all of the exhaust valves are on the L-side of the cylinder—see fig. 5. There are eight cams on the cam shaft.

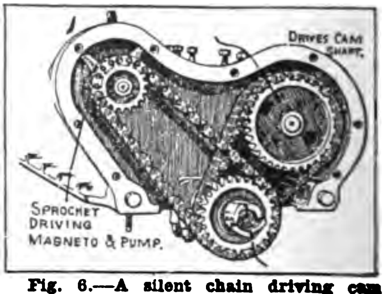


Fig. 6.—A silent chain driving cam shaft and magneto.

Valve Caps.

Where valves are on the side and the head cast integral with cylinders, valve caps are screwed over the valves in the cylinder (see figs. 7, 8, page 90, also chart 32). By removing these caps the valves can be lifted from their seat and ground. There are two valve caps to each cylinder; an **inlet valve cap** and an **exhaust valve cap.**

Compression or Relief Cocks.

Consist of small pet cocks screwed into the exhaust valve caps. By opening when the engine is running, it is possible to see if any of the cylinders are missing fire. A flame will shoot out if firing. If mixture is right the flame will have a blueish color. They are also used for injecting gasoline in winter when engine is cold and hard to start—see chart 32, page 64. The S. A. E. now term this a "priming cup."

*Cams and Cam Shaft—see chart 40.

A cam is a device that produces intermittent motion. When an object is in motion part of the time and at rest between motions, its action is said to be "intermittent." A cam may best be described as a wheel with a hump or nose on one side (figs. 1 and 2), or in other words, it is a piece of metal revolving with a shaft, part of its circumference being farther from the shaft than the rest. The part of the cam that projects is called the **nose.** Anything resting against the cam will be moved only when the nose comes around to it; otherwise it remains stationary.

For a four cylinder engine, four cams on the inlet cam shaft are shown in chart 40, fig. 7. Four more cams on an exhaust cam shaft are provided on the opposite side of this engine, because it has "T" head cylinders. The cams are divided in four positions on the cam shafts, and are made in one piece or integral with the cam shaft. If the cylinder is "L" type then all cams would be on the one cam shaft—see fig. 9, chart 40.

†For each cylinder there is one inlet cam and one exhaust cam. The **exhaust cam** usually has a **broader nose** because it must hold the **valve open longer.**

The cam shaft, also called the "secondary" or "half time shaft," has a cog wheel or gear, called a *timing gear, on one end, which meshes with the drive shaft gear on the crank shaft.

When the crank shaft revolves, the drive gear on the crank shaft drives the timing gears, which drive the cam shaft and thereby rotate the cams.

The nose of the cam raises a valve lifter or tappet, which plunges against the end of the valves and raise them from their seat. When the nose of the cam is under the roller or valve lifter, the valve is held open; the valve is closed after the nose passes, by the action of a strong spring. (see page 92.)

The valve stem being held in a valve guide, cannot move in any direction but up and down. Thus the steady **rotary** motion of the cam is changed to the **intermittent** motion of the valve.

As has been shown on four cycle engines, **each valve opens only once** while the crank shaft makes two revolutions. Therefore the cam shaft should revolve only once while the crank shaft revolves twice.

‡Timing Gears and Silent Chains.

If two gears running together (or in other words, in "mesh"), have the same number of teeth they will make the same number of revolutions.

---

*For setting cams, see valve timing instruction No. 9. Also Dyke's 4 cylinder engine model.

†Special racing type engines, as the Stutz, page 109, have two inlet and two exhaust valves, and as many cams. The White also.

‡For "adjustment of timing gears," "silent chains," etc., see index.

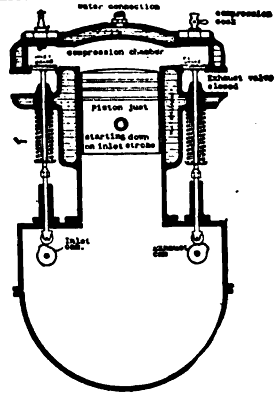
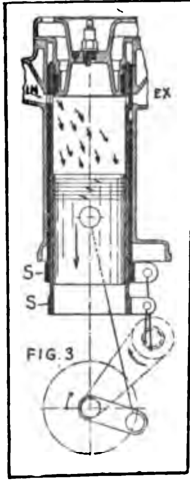


Fig. 1—Poppet Type of Valve; so named because the valve pops up and down. There are two valves to each cylinder; an inlet and an exhaust valve. This type of cylinder is a "T" head, therefore valves are on opposite sides.



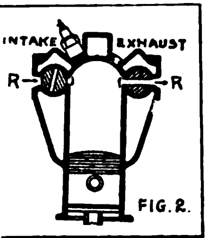


Fig. 2—The Rotary Valve—see chart 70

Fig. 3—The Sleeve Type of Valve; there are two sleeves with openings at upper end. When their openings are together, the fresh gas is admitted or burnt gas discharged. "IN" means inlet, and "EX" exhaust. (See Chart 68 and 69.)

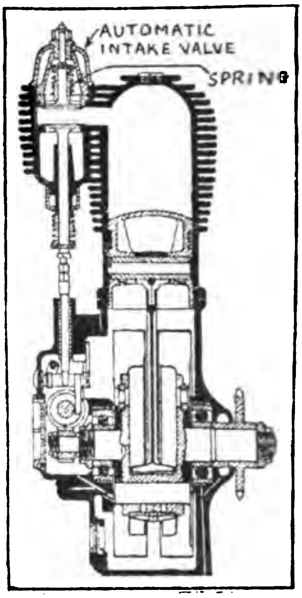


Fig. 4.—Automatic Type of Inlet Valve. Suction of piston draws the valve open against the tension of spring.

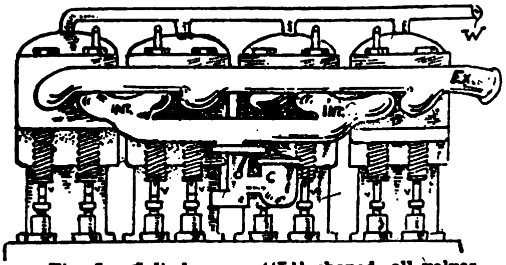


Fig. 5.—Cylinders are "L" shaped, all valves on one side. Note the four inlet and four exhaust valves on four cylinders. These valves are the "poppet" type and are mechanically operated.

To remove valves; there are valve caps over each valve.

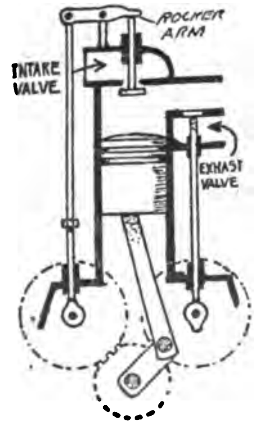


Fig. 6.—Overhead Mechanically operated Inlet Valve and side Mechanically operated Exhaust Valve on "F" type of cylinder. The inlet valve in this instance would be "Cage" type (Fig. 4, page 90). The cage with valve is screwed into cylinder head.

To remove the Inlet Valve the cage with valve is screwed out. To remove Exhaust Valve a valve cap over the valve is removed

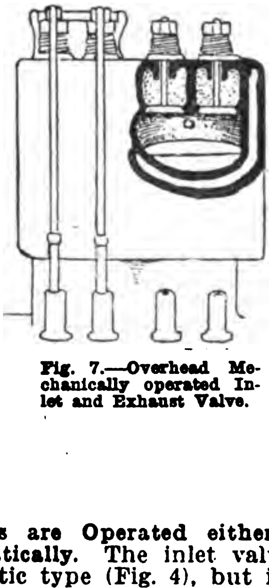


Fig. 7.—Overhead Mechanically operated Inlet and Exhaust Valve.

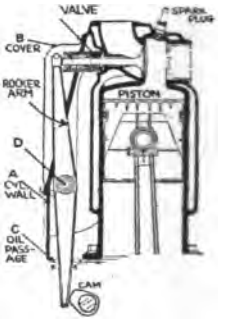


Fig. 10.—The Duesenberg principle of operating Valves from the side. There are 2 inlet and 2 exhaust valves per cylinder.

Valves are Operated either Mechanically or Automatically. The inlet valves can be of the automatic type (Fig. 4), but is seldom used for automobile work. It is used to some extent on the single cylinder motorcycle engine and quite often on light duty stationary engines.

The Exhaust Valve is always Mechanically Operated, in fact it could not be operated automatically by suction.

There are different Arrangements for Operating the Valves Mechanically as explained,

The Sleeve and Rotary Valve would be classed as mechanically operated.

See Figures 5, 6 and 7 for Various Arrangement of Valve Operation. Also Chart 66 of Wiedly overhead method.

HART NO. 43—Valves; types, construction and operation.

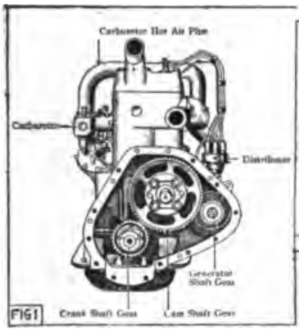
ote—Fig. 6 would be termed an "F" head type engine, see page 90, fig. 4.

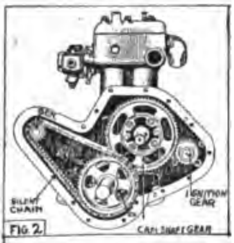
‘‘ on page 85.

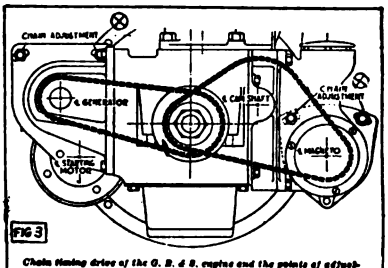
If the **driven** gear has twice as many teeth as the **drive** gear, it will revolve only once while the other revolves twice. This is called a "two-to-one" or "half time" gear.

Because the cam shaft must revolve only once while the crank shaft revolves twice, the cam shaft gear has twice as many teeth as the crank shaft drive gear. See chart 40, fig. 3, for an example—and below.

The cam shaft revolves in **opposite** direction to crank shaft when driven by gears without an idler and **same** direction when driven by a silent chain or an idler.







Chain timing drive of the G. B. & S. engine and the points of adjustment for taking up slack in it

The wide face helical gear is most popular for the timing gears. Special material as fabroil, micarta and other compressed materials are used by many as material for making gears which are silent. Drop forged gears are also used to a great extent. Also steel for the crank shaft gear and cast iron for the cam gear.

The silent chain for driving the generator is quite popular and it is also being used to a certain extent for driving the cam shaft. The object is to obtain quieter running. This type of chain must not be confused with the ordinary roller type as used on chain driven trucks. The silent chain is more positive in action, otherwise the timing would be thrown out of adjustment.. The teeth on a sprocket used for a silent chain are very close together and accurately made.

Any undue slack in the chain can be taken up by sliding the magneto or generator shaft outwards (see fig. 3). This chain is self-adjusting for pitch.

Engine Valves.

Purpose of valves: There are †two valves to all four cycle gasoline engines; an **inlet** valve and an **exhaust** valve. By referring to charts 29 and 26 the location and purpose of the valves will be understood.

Types of valves: There are three types in general use; the "poppet," "sleeve" and "rotary" (see chart 43). The poppet type being used almost exclusively.

The inlet valve admits fresh gas to the cylinder. As fresh gas is going into the cylinder during only one stroke of every four, the inlet valve is opened during only one stroke of every four, or in other words, during one stroke of every two revolutions of the crank.

The exhaust valve permits the burned and useless gas to escape. It is opened and held open by a cam on the cam shaft. This is termed "mechanically" operated.

Direction of travel of fly wheel and cam gears: When standing behind a fly wheel on an automobile engine it turns to the left, whereas standing in front of engine it turns to the right. Also note the direction of rotation of cam gears, fig. 2, chart 29.

†There are a few engines using four valves for each cylinder, see page 109, fig. 3.

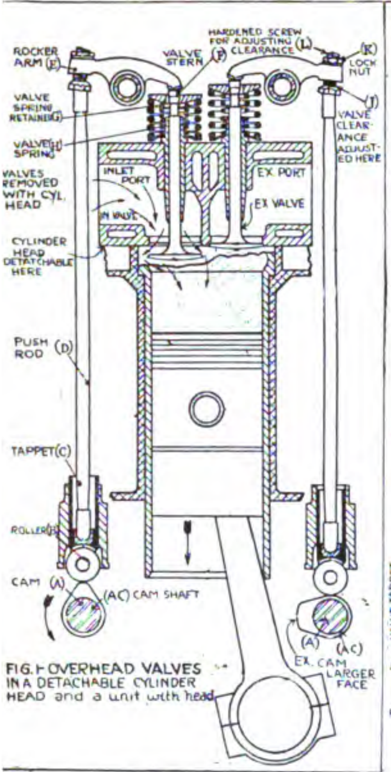


FIG. 1- OVERHEAD VALVES IN A DETACHABLE CYLINDER HEAD and a unit with head

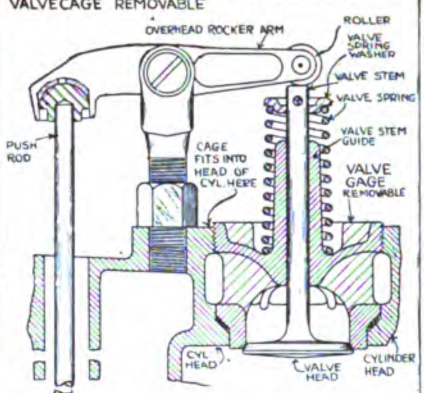


FIG 2- OVERHEAD VALVES - IN A SOLID CYLINDER HEAD VALVECAGE REMOVABLE

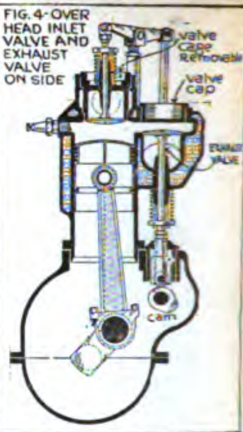


FIG. 4- OVER HEAD INLET VALVE AND EXHAUST VALVE ON SIDE

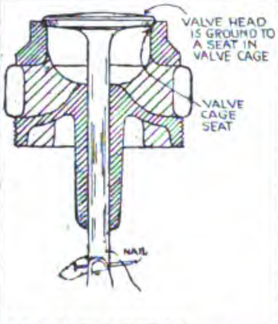


FIG 3- CAGE REMOVED AND TURNED UPSIDE DOWN SHOWING METHOD OF GRINDING VALVE IN CAGE SEAT

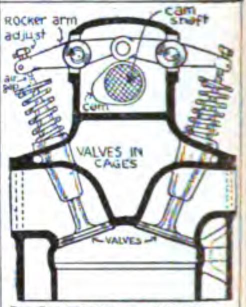


FIG. 5- OVERHEAD VALVES IN CAGE OPERATED BY OVERHEAD CAM AND CAM SHAFT

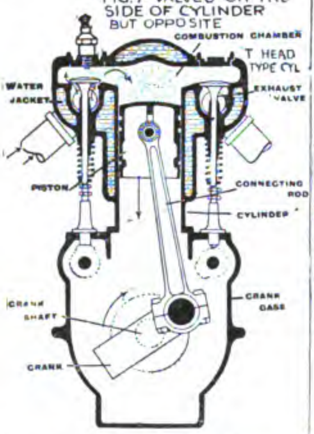
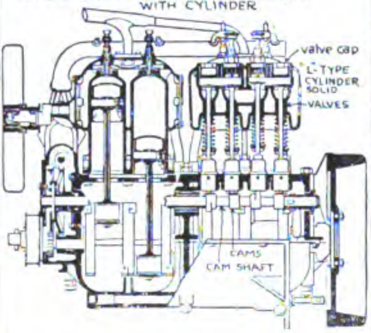


FIG. 7- VALVES ON THE SIDE OF CYLINDER BUT OPPOSITE

FIG. 8- VALVES ON THE SIDE ALL VALVES ON ONE SIDE CYLINDER HEAD INTERGRAL WITH CYLINDER



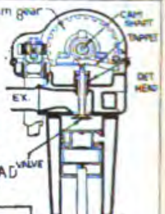


FIG. 6- OVERHEAD VALVE IN DET. HEAD OPERATED BY OVERHEAD CAM AND CAM SHAFT - SEE PAGE 132

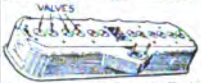


FIG 6A- DETATCHABLE HEAD OF FIG 6 TURNED UPSIDE DOWN VALVES GROUND IN HEAD

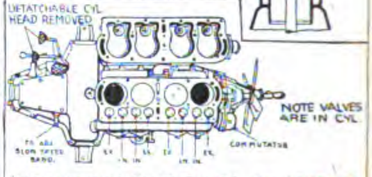


FIG. 9- VALVES ON THE SIDE ALL VALVES ON ONE SIDE_CYL HEAD DETATCHABLE (Ford)

Valve construction: There are two different valve constructions in general use; (1) the **overhead;** (2) the **side.**

The overhead valve may be divided into two types; (1) the overhead valve in **a detachable** cylinder head and a unit of the head; (2) the overhead valve in a **cage and a separate unit** from the head.

The operation of the overhead valve may be divided into two methods; (1) by **push rods,** per figs. 1 and 2; (2) by an ***overhead cam** shaft, per figs. 5 and 6.

The side valve construction may be divided into two constructions (1) where **inlet valve is** located in cylinder head on one side and exhaust valves on the other or **opposite, as per** fig. 7; (2) where all valves are on **one side. The operation of the side valve** is **invariably by a cam** and tappet lifting the valve.

Cylinder head on side valve cylinders may be cast **integral** with **body of cylinder as per figs.** 7 and 8 or **detachable** as per fig. 9.

A combination overhead and side valve arrangement is shown in fig. **4. This type is** called the "F" type. The head could be **detachable** with valve in the head, or **cage type with head integral with cylinder.** With this type, the usual method is to operate the **inlet overhead,** and the exhaust from the side, both being operated from a single **cam shaft.**

HART NO. 42—Valve Construction and Relation of Valves to Cylinder.

hart No. 44 is on page 94.

---

*overhead **cam-shaft** with overhead valves is the popular method used on airplane engines—**see pages 911 to 916.**

Mechanically operated valves are opened and held open by means of cams **and** closed by means of a strong spring. (see chart 44.) The exhaust valve **is always** mechanically operated.

Inlet valves are generally mechanically operated, but some of the old and motorcycle type of engines have valves of the "automatic" type.

Automatic operated valve is held against its seat by **a** light spring—see **chart** 43, fig. 4. During the suction stroke, the sucking action of the piston **as** it travels downward in the cylinder, draws the valve open. At the end **of the** suction stroke, when the suction ceases, the spring forces the valve disc **back** to its seat, and the **gas** is prevented from escaping through the valve.

It must be understood that the valves of a gasoline engine always open inward. Thus the pressure from the power and compression strokes tends to keep them firmly on their seats.

Usually inlet and exhaust valves are made the same size. Some manufacturers are making the inlet larger, for instance the Sterling engine has 1¼ inch inlet valves and 1⅛ inch exhaust valves. **The lift of a valve** is the height it is raised from its seat by the cam.

Valve Operation and Location.

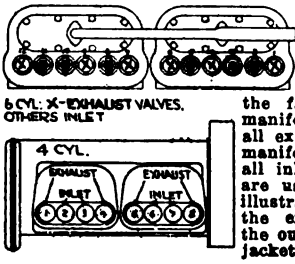
The "mechanically" operated "poppet" type valve is the type in general use, therefore we shall confine our attention to this type.

Valves are operated; or opened by the intermittent motion of a cam and closed by a strong spring, as explained under "cams" on page 87.

****The cam shaft may be overhead or on the side,** as per page 90.

The location of the valves are **overhead** or on the **side** as per page 90, or a **combination** as per fig. 4, page 90, which is termed the "F" type.

Overhead operated valves may be in a detachable head of cylinder or in **cages** as per figures 1, 2, 5 and 6, page 90.



On "L" head type of cylinders. all inlet and exhaust valves are on one side, but they do not run consecutively. Owing to the fact that the exhaust manifold must connect with all exhaust valves and inlet manifold must connect with all inlet valves; the valves are usually arranged as in illustrations above. Note **the exhaust** is always on **the outside next to the water jacket.**††

Illustration at top, is that of a 6 cylinder engine. The one at bottom, 4 cylinder.

Side operated valves may be placed all on **one side,** or **opposite sides** of cylinders. When on opposite sides, two cam shafts are necessary; one on each side—see fig. 7, page 90. When all valves are on one side or overhead; one cam shaft is sufficient—see figs. 8, 1, 2, 4, 5 and 9, page 90.

†To grind valves in an overhead valve engine with detachable head, the head is removed, and valves are ground in the head (fig. 6A, page 90)—unless valves are in a cage.

To grind valves in an overhead valve engine with "**cage**" **type valves,** the valve is ground in the "cage" as per fig. 3, page 90.

To grind valves on a side valve engine, the **valve caps** are removed if head is integral with cylinder as per figs. 7 and 8. If head is **detachable** as per figure 9, then **head is removed** but valves are **ground in their seats in the cylinders.**

Although the valves vary in location and methods of operation, the principle or purpose remains the same; the inlet to **admit fresh gas,** and the exhaust valve opens at the correct time to **expel** the **burned gas.**

---

*Valves are made of cast iron electrically welded to a steel stem. They are also made of nickel steel or Tungsten steel. The latter being considered best.

†See index for "valve grinding." **See foot note page 90. ††The spark plugs (S) are usually placed over inlet valves, per page 121.

A "poppet" type valve has three parts; a "head;" a "stem," which forms the moving part, and a "valve face" which seats into a "valve seat." This valve face is beveled and is perfectly round. When seated, it must fit the valve seat perfectly tight, otherwise during compression stroke the gas would leak and on power stroke, a loss of power would result, by the valve leaking at the seat. Therefore it is ground to this seat.

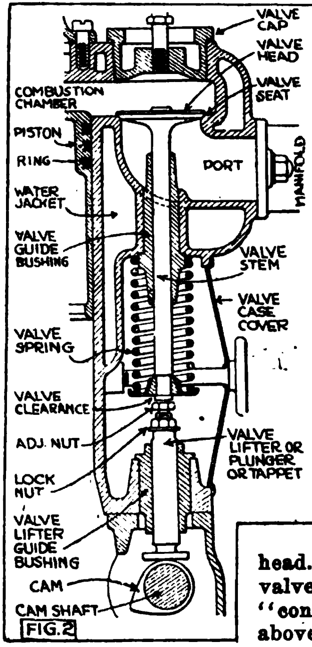


FIG. 2

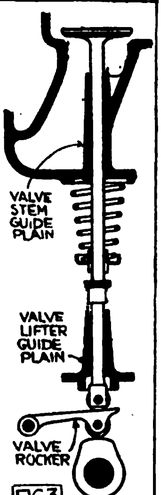


FIG 3

The exhaust valve requires more grinding than the inlet valve because the hot gases pass out between the valve seat and valve face when valve is raised. When the valve is opened, there must be sufficient space to let the burnt gas pass freely.

The valve spring holds the valve tight in its seat and must have sufficient tension at all times (see page 635). If too strong, the valve will close with more noise. **If too weak** valve will not seat properly. The exhaust valve spring usually weakens first on account of greater heat.

The valve spring retainer and lock, formerly called valve spring washer, is placed at bottom of spring and held in place by a two part lock. Formerly a "key" passed through a hole in the valve stem (see page 630, fig. 1).

Valve face is the beveled part of valve head. **The valve seat** is the part of cylinder head in which valve face is placed. The valve face and seat can be "conical" or "flat." They are usually conical as per fig. 2 above, and fig. 7, page 94. **Valve head** is upper part of valve stem.

Valve stem is the stem part of valve head. The stem of a mechanically operated valve on "L" or "T" head cylinder of the "side valve" principle, usually extends about half way down to the cam shaft. A valve lifter then lifts the valve stem by action of a nose on cam as cam revolves. (see page 87.) To set this cam, to raise valve at the proper time, is called "valve timing."

On engines with overhead valves, there is a rod, called the "**push rod**," between valve lifter and rocker arm, see fig. 4, page 94.

Valve clearance also called "air-gap," is the distance between lower part of valve stem and valve lifter. On the push rod type, it is usually between rocker arm and end of valve stem. This distance is regulated by an adjusting screw.

Valve lifter, also called "valve plunger," "valve tappet" and other names, is the part placed between valve stem and cam. The top part has an adjustable screw which can be slightly raised or lowered to get correct valve clearance. **The bottom of this valve lifter** is sometimes fitted with a "roller," per fig. 3, page 94. The mushroom type, fig. 2 above, and figs. 1 and 2, page 94 is the type used most.

A valve rocker—upper, is used on overhead valves, also called "rocker arm;" **a valve rocker—lower**, is the principle shown in fig. 3. It is also called a "side tappet lifter." The latter is seldom used.

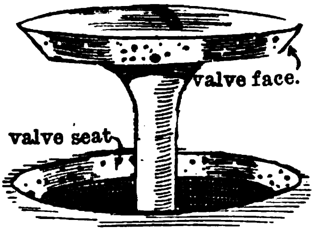
A valve stem guide holds the part through which the valve stem passes. Sometimes it is "bushed" as shown in fig. 2, also see page 634, fig. 7. Quite often it is plain as per fig. 3.

A valve lifter guide (also called "plunger" and "tappet" guide), is shown in fig. 2, which is fitted with a bushing and can be renewed when worn. It is bolted, sometimes screwed to crank case (see also page 54). In fig. 3, a plain guide is shown.

Enclosed valves are where a cover fits over valves (fig. 2). This deadens the noise of lifter striking valve stem and keeps out dust. Also see page 121.

Although valves may be placed overhead, or a combination, as overhead and on the side—the principle of operation is very much the same. (see page 90.)

**Purpose of Valve Grinding.



No. 4.—A pitted valve and seat.

The exhaust valve is surrounded by flame when open, and will become "pitted" (fig. 4.)

The inlet valve admitting gas instead of ejecting a flame does not pit as badly as the exhaust valve.

In a perfect seated valve, the valve face and seat are smooth and even, with dull gray surface. **A pitted valve** is rough, uneven, and full of tiny holes, and cannot come to a tight seat. Therefore valve must be ground.

The process of grinding a valve is the placing of a grinding paste between the valve face and the seat, and the revolving of the valve until the roughness is worn down. See index for "valve grinding" and "valve re-seating."

---

*The "tulip" shaped valve is another type of inlet valve seat but now seldom used—see page 128.

**See first paragraph this page and pages 628 to 632. *See foot note page 94 for valve material.

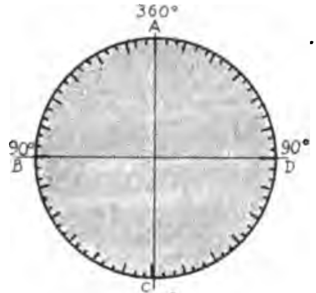


FIG 1

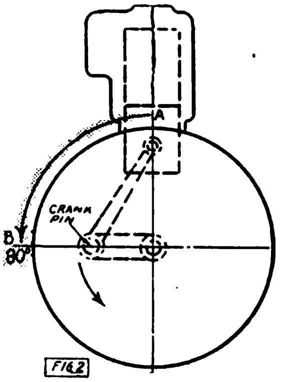


FIG 2

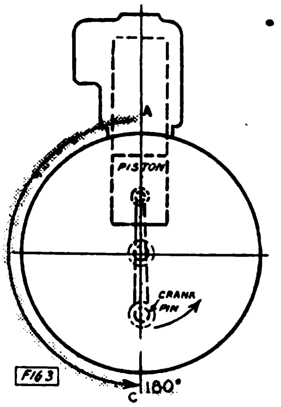


FIG 3

Fig. 1. Example; suppose we take a fly wheel and divide its circumference into 360 equal parts; each part would be a degree—expressed with a small "o" as 360°.

In fact, any perfect circle can be divided in degrees. The crank shaft revolves in a circle, therefore we will designate the travel of the crank shaft in degrees.

One half of the circle would be 180°, which would represent a stroke of the piston, or a half revolution of the crank. One quarter of the circle would be 90°, one third of the circle would be 120°.

Any circle, or say, travel of the crank pin, would represent 360° when it made a complete circle or revolution.

Fig. 2. Example; piston has traveled down from upper dead center, one quarter of the circle or one-half of a stroke; crank pin and fly wheel have turned 90°.

Fig. 3. Example; piston has traveled from top dead center to bottom of stroke, or one half of a revolution; fly wheel and crank pin have traveled 180°.

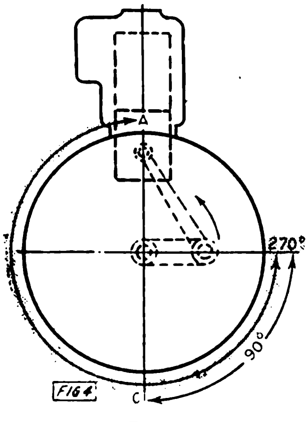


FIG 4

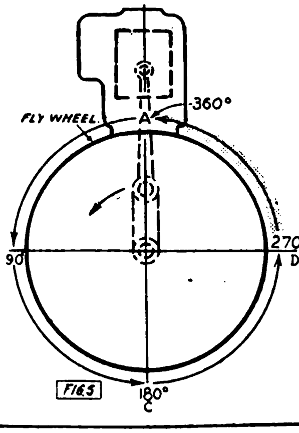


FIG 5

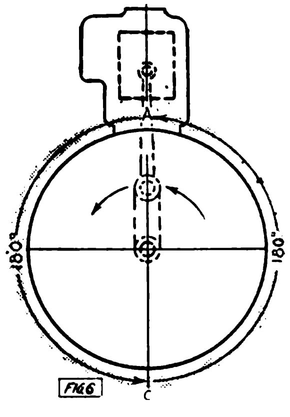


FIG 6

Fig. 4. Example; piston has traveled up from bottom, one-half of a stroke; crank pin and fly wheel have traveled one quarter of a circle from bottom or 90° from C to D. In all, the crank pin and fly wheel have traveled from A to D, three quarters of a revolution or 270°.

Fig. 5. Example; the piston has made two strokes, one down and one up, therefore crank pin and fly wheel have made a complete revolution or traveled 360° in all.

The idea is to learn that the crank pin travels in a circle and the fly wheel travels in a circle, and a revolution is a complete circle, and a complete circle is 360°.

The piston travels in strokes, each stroke representing a half revolution of crank.

If we spaced off 360 marks, equal distance apart, on any circle, then each mark would be called a degree. In fig. 1, we have spaced off the marks as 5 degrees each.

Now we can divide each degree into say, sixty equal distances apart and call each part or mark, a "minute."

We could go still further, and divide each minute into sixty equal distances apart and call each part or mark, a "second."

A minute is usually expressed with a single mark after the figure, as, 25′.

A second with two marks, as, 25″.

Example; express, ten degrees, six minutes and five seconds. It would be as follows; 10° 6′ 5″.

Note—To find the circumference of a fly wheel; multiply the diameter in inches by 3.1416. If the circumference is then divided by 360, the distance or portion of the fly wheel circumference equivalent to one degree may be ascertained.

CHART NO. 45—Explanation of the Meaning of Degrees, Minutes and Seconds. Note; Crank Shafts on Engines usually turn to the right—(When in front). On above illustrations we are supposed to be standing in the rear of fly wheel, turning it to the left which would cause crank shaft to turn to the right (from front).

Chart 43 on page 88.

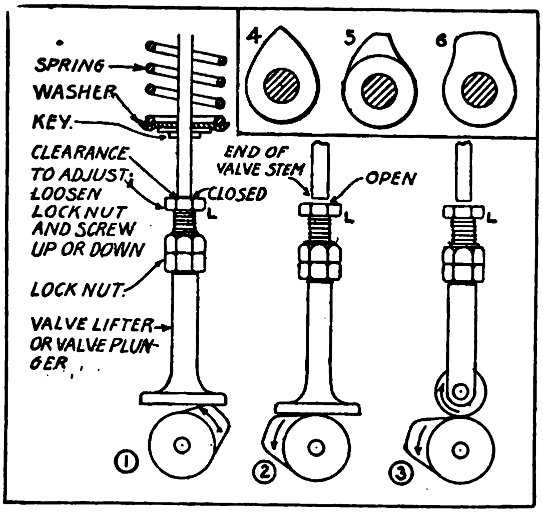

SPRING
WASHER
KEY
CLEARANCE TO ADJUST; LOOSEN LOCK NUT AND SCREW UP OR DOWN
LOCK NUT
VALVE LIFTER OR VALVE PLUNGER
END OF VALVE STEM
CLOSED
OPEN
L
L
L
4
5
6
①
②
③

Fig. 1-2.—Mushroom type of valve lifter.

Fig. 3.—Roller type valve lifter.

Note in Fig. 1; valve just starting to lift. Figs. 2 and 3, valve just closed.

Exhaust cams usually have broader nose than inlets, because the exhaust valve remains open longer.

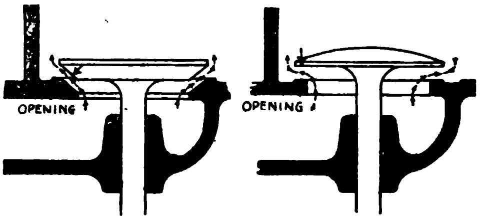


Fig. 7.—Note the "flat" and "conical" type of valve. It is said, the flat valve gives **greater** opening for the same valve lift and has greater possibilities for high speed work, however, it is **seldom** used.

*Valve Clearance.

This subject is explained on page 110. **An example of adjusting the valve clearance on a "side valve" engine** will be given here.

Valve clearance means the distance between **the** end of valve and the end of tappet or plunger **which** lifts it.

When an engine becomes noisy and a clicking noise is heard, the trouble is likely in the **valve** ends having worn or the adjustment nut **become** loose.

This adjustment can usually be made by screwing up on the adjustment screw (fig. 5) **and then** locking the position with lock nut.

The clearance is necessary in order that the valve seats properly and should usually be from .003 to .005 of an inch **when engine is cold. The amount** of clearance for different engines is given **under,** "standard adjustments of leading cars"—see **index.**

The adjustment should always be made—after the valves of an engine are ground or when checking the valve timing.

The procedure to adjust is as follows: turn fly wheel of engine over until the other tappet and valve in the same cylinder is up as far as it will go, or the valve wide open. The first valve will then be closed. As previously stated there should be from .003 to .005 of an inch between the head of the tappet screw and the end of the valve stem.

If it is found that the clearance is not right, loosen the lock nut on the tappet screw and turn the screw up or down as may be required to obtain the correct clearance.

It is best to use a "thickness gauge" (page 700), but if a gauge is not obtainable a piece of newspaper will serve as a gauge, a sheet of ordinary newspaper is between .002 and .003 of an inch in thickness.

After the tappet screw is adjusted so that the clearance is correct, tighten the lock nut.

"Back lash" or lost motion **in the cam shaft driving gears** should be taken up in direction of rotation when clearance is adjusted.

A noisy valve tappet, caused from wear, and **where no adjustment is provided,** can be, in some instances repaired by placing fibre or steel washers under or over valve ends.

To adjust valve clearance on overhead valve engines—see fig. 1 on page 109.

The opening and closing time of the valve is not when the lifter begins to rise or comes to rest but when it makes or leaves contact.

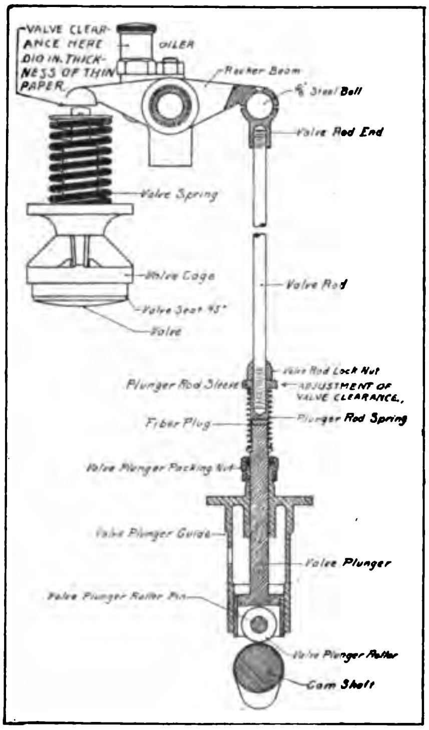


Fig. 4.—To adjust valve clearance with valves of the overhead type as the Buick and **Dorris**—the valve rod is lowered or raised. **Note illustration for clearance on the Dorris—between end of valve and rocker arm. Also see page 109, adjusting "push rod clearance" on the Buick—which means "valve clearance."**

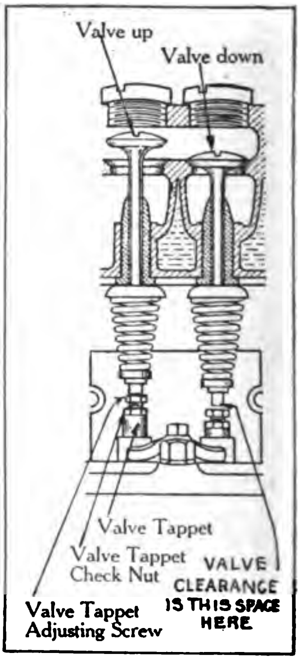

Valve up
Valve down
Valve Tappet
Valve Tappet Check Nut
VALVE CLEARANCE IS THIS SPACE HERE
Valve Tappet Adjusting Screw

Fig. 5.—Type of valves on side of "L" head engine—clearance is adjusted as shown in illustration. (Hudson six.)

Grinding and Reseating Valves.

If valves become pitted and leak, they need re-grinding. If warped or shoulders form in the seat, then the seat and valve ought to be refaced. **See index "Grinding Valves," "Reseating Valves."**

CHART NO. 44—Valve Clearance. Valves and Cams. See repair subject and index for valve grinding. See "Standard Adjustment of Leading Cars" for valve timing on different engines.

(Chart 46 on page 100). *See pages 631, 634 and 630.

INSTRUCTION No. 9.

*VALVE TIMING: Valve Clearance. Meaning of Degrees. Periods of Travel of Cam during the Four Strokes. Examples of Valve Timing.

Before the reader can thoroughly master the subject of valve timing he must first **learn the four cycle principle** as explained on page 57 to 59, as it is with this principle we will deal. In addition to the above, the **meaning of degrees** as explained in chart 45, and the **relation of the valve cam speed to the engine crank shaft speed** and the importance of **valve clearance adjustment** must be thoroughly understood.

Valve Clearance and Lift of Valve.

If no space was left between the end of valve stem and the cam, even very slight wear of the stem and seat would prevent the valve from closing properly. Furtherfore there must be some cognizance taken of the expansion due to heat. As the stem expands, it gets longer so if no clearance were provided the stem would rest against tappet and be unable to seat properly.

****Valve clearance, also called "air gap" space, is the space between the end of valve stem and the lifter or plunger.** The width of this air gap ranges from the thickness of tissue paper to 1/16 of an inch. The average gap is somewhere about or slightly less than postal card thickness (see index; Standard Adjustments of Leading Cars).

Some manufacturers give about 1/1000 of an inch less space to the inlet than the exhaust, because the exhaust valve stem lengthens more; due to greater heating. For instance, Hudson gives .004 of an inch to the "air space" on the inlet valve and .006 to the exhaust.

The adjustment should always be made with engine **cold** and **after** the valves are ground, as the grinding may slightly lower valve.

The valve lift: the inlet cam has a sharp nose. The exhaust cam has a broader nose, because it must hold the valve open longer. The height of the nose **less the air gap,** regulates the lift.

The average lift of either exhaust or inlet is approximately, 3/8 or 9/32 of an inch. It is thus evident that if the air gap is 3/8 or 9/32 inch too large, the valve will not open at all.

Now if the air gap (3/8 inch) is slightly decreased, the valve will lift very slightly and stay open but a few degrees. If the air gap is again slightly decreased, the valve will open sooner, raise higher and close later. This process can be repeated until there is no air gap left.

Therefore, suppose an engine was designed to have 1/16 inch air gap and there was no air gap at all; the valves would open possibly 50° too soon, raise 1/16 inch higher than intended and close 50° too late.

As to wear of end of valve stem or tappet; it is apparent that as the wear increases, the space or air gap increases and valves will have **less** lift, **open late and close early** and become more noisy. All of which will affect the power of engine.

---

*For valve grinding and other repairs, see "repairing instruction."

The study of valve timing will be simplified if the reader will refer to Dyke's four and six cylinder engine models. **Valve timing** of **leading automobile engines** given in "Standard Adjustment of Leading Cars," see index. **A table for converting degrees** into inches, and fractions of hundredths into sixty-fourths of an inch is given in chart 51, page 115.

**On actual tests it has been found that by adjusting the air gap properly almost double compression and more than double power has been secured.

When valves are noisy the cause can usually be traced to the wear of valve stem, although they are case hardened at end as well as the head of tappet, the wear however, will come in time. Too great a lift will also cause noise.

***Remember; always adjust valve clearance** according to measurement given by the manufacturer.

It is essential that the valve clearance adjustment be made **with the "back lash" or lost motion in the driving gear entirely taken up** in direction of rotation.

Remarks on Inlet Valve Opening and Closing.

We have explained that the valves are raised by means of cams operated by a cam gear placed on the front of the engine in mesh with a gear on the crank shaft.

Inlet valve opening: if, when one of the cams raise an inlet valve just as the piston is starting down on the suction stroke, then a charge of gas will be drawn into the cylinder as long as the piston is on the suction stroke and the valve is open.

Therefore the valve ought to open in time to give the piston a chance to draw in a **cylinder full of gas.**

If the valve were to open much after the time the piston was starting its suction stroke, then it would not get a full cylinder of gas, and thereby give less power.

Therefore it is important that the inlet valve be made to open exactly **at the right time,** and the method employed to cause it to open at the right time is through the inlet valve timing gear and the proper valve clearance (**see pages 94 and 95**).

The practice is to allow the piston to descend slightly in the cylinder on the suction stroke before the inlet valve opens, so as to reduce the pressure and create, if anything, a vacuum which causes a greater suction.

Inlet valve closing: when we come to the closing of the inlet valve we find the practice almost universal of leaving the valve open until the piston has not merely reached bottom dead center, that is, the bottom of the stroke, but has actually traveled slightly up on the compression stroke again.

It seems as though the gas already sucked in would be forced out again, but we are forgetting the speed of the engine—15 complete cycles of operation in one second, or one stroke of the piston to a one-sixtieth part of a second; such a speed that the piston has reached the bottom of its stroke an appreciable time before the gas has been able to fill the cylinder, so that even after the piston has started to move upward on the compression stroke, there still remains suction in the cylinder which, if the valve remains open, will continue for a short interval to draw in a further charge of gas.

Obviously the exact point at which the inlet valve should close depends upon the speed of the engine, and whatever setting is arranged, it will not be equally suitable for all the speeds attained by one engine.

As, for instance, when the engine runs dead slow, the late closing would be a distinct disadvantage—the gas being partially driven back on the compression stroke, while at maximum speeds the valve will close before the suction has finished its work.

However, there is an average speed for every engine, and the valves are set to it accordingly.

---

*See page 542.

Remarks on Exhaust Valve Opening and Closing.

Exhaust valve opening: when we come to the opening of the exhaust valve, there are no two opinions about it.

The valve must open considerably before the piston reaches the end of the explosion stroke, and if this wastes some of the force of the explosion, it is amply compensated for by the freedom afforded the piston in commencing the exhaust stroke.

It would obviously be wrong to keep the exhaust valve closed up to the very moment, before the piston is about to move upward, because on commencing the exhaust stroke it would find itself confronted for an instant with the force which had just driven it down, and until the valve was wide open, it would be considerably impeded on its journey.

So the exhaust valve is usually opened as soon as the piston has moved through about seven-eighths of the power stroke; that is, before bottom dead center.

Exhaust valves opening too early causes a waste of power. Stationary gasoline engines, which run at much lower speeds than automobile engines, do not hold their valves open so long, the chief difference being in the times of exhaust opening and inlet closing.

Other effects of valve timing are dependent upon the short or long stroke, the side valve, as in the "L" head, the opposite valves as in "T" head, and the overhead valves, high and low compression. All this must be considered in valve timing.

The term "valve timing" refers solely to the points at which the valves open and close and does not in the present section include the **height** to which they lift. (see **page** 95.)

The most sensitive point in the cycle of a four cycle engine is the **top center position**, between the exhaust and induction strokes, for the reason this is the critical scavenging point.

At a certain point **before the bottom** of the firing stroke, the **exhaust valve is opened**, and kept open during the succeeding exhaust stroke, to enable the ascending piston to expel as much of the exhaust gas as is within its sphere of action, but, having come to rest at the top of its stroke, there is still the contents of the **combustion head** yet to be dislodged.

Exhaust Valve Closing.

As to when the exhaust valve should close, there is but little to be said about it. Suffice it to say that it may not close before the end of the stroke.

As a rule on account of what we have explained about the gas which remains in the head of the cylinder being slightly under pressure at the end of the stroke, the valve is quite often allowed to remain open until the piston has moved slightly down on the induction stroke, so as to give full opportunity for as much exhaust gas to escape as possible.

In order to understand just how important it really is to expel all of the burned or exhaust gas, it must be explained that one of its chief constituents is **carbon dioxide**—which is the most powerful anti-combustion agent known to science. Its presence, therefore, even in small quantities, retards considerably the speed of the explosion development.

The piston now having come to **rest at the top**, we are still faced with the problem of dealing with the volume of burned gas which remains, and for the expulsion of this we must take advantage of exhaust momentum.

The manner in which this principle operates will be apparent if the contents of the exhaust pipe is pictured as a mass of gas moving outwards with explosive velocity. When the influences which started this movement have ceased—namely, at top centre—the gaseous mass will function almost like the piston of an extractor pump, and if the valve timing permits of it will tend to withdraw a large proportion of the residual gases from the cylinder head.

It will now be obvious from the foregoing that, if the extractor action of the exhaust gases is to be taken advantage of, **the valve must be made to close a little later than "top center,"** or—as it is technically described—**must have** a certain degree of "**lag**;" for it is evident that if we close it at the **exact** top of the stroke the contents of the combustion head (which we wish to get rid of) will be imprisoned and will **contaminate the incoming charge.**

The amount of this "lag" will depend on several things—the shape of the combustion head, the weight of the valve, the strength of the springs, and design of the exhaust system.

Valve Effect of "Lag" or Bounce.

As regards valve spring, strength and weight, this has to be reckoned with on account of its influence on **inertia** lag as distinct from that which is **intentional**, for it is well known that as the speed of the engine increases the valve tends to "jump" the closing face of its cam and closes later and later as the speed increases. This is what we describe as "inertia lag." There is a point however, past top center that the exhaust extraction lasts, and pending this extracting effect the valve should remain open, but if carried beyond this point, a reverse of the exhaust gases may occur, for it must not be forgotten that the piston has now started down on its suction stroke. It becomes a question therefore, of closing the valve when the scavenging is as complete as possible.

*The best design of cylinder head for an "overlap" is the round or "I" head with overhead valves; the ordinary "L" head is not so good, and in certain kinds of heads in which the inlet and exhaust valves are small and close together in a small pocket an overlap is quite useless.

On the other hand, it has been found in racing practice, where the exhaust pipe is very long, straight and open, and the combustion head suitable for scavenging, that a very considerable overlap can be allowed with advantage.

In some instances however, the exhaust valve is made to close on top, for instance, the Locomobile engine which is a "T" head type (see page 108).

What Governs the Valve Timing.

The different size of cylinder, especially in the stroke and in the type of ignition, shape of manifold and the speed of engine, govern the valve timing.

Early setting of valves on an engine will cause irregular running at lower speeds, unless a very heavy fly wheel is used. It will also increase the gasoline consumption in short stroke engines.

For high speed work, the inlet may be opened and closed late. **For slow speed work,** closing the exhaust and inlet on center, gives the best control, and no blowing back.

The time of opening and closing of valves with reference to the engine speed, of course has an important bearing on its performance. **If the valves open too early it will cause back-firing,** while if they open too late a sluggish engine and overheating will result.

High speed (short stroke) engines, have a longer time of valve opening than medium or slow speed engines. The slower speed engines have the exhaust opening and the inlet closing, nearer to bottom center, while some high speed engines open the exhaust 65° **before** bottom center and close the intake 70° **after** bottom center.

Valve timing of different engines will vary according to its intended average speed and the length of stroke. Long strokes are for slower speed engines than short strokes. Obviously high-speed engines are not efficient at slow speeds, because the inlet closes too late and the exhaust opens too soon, thus losing part of the charge and part of the power stroke. And slow speed timing on a high speed engine does not permit of receiving a full charge nor of getting rid of the back pressure during the exhaust stroke.

The value of the design of the cam, can and nearly always is, lost through improper valve clearance or air gap adjustment (see pages 95-107).

---

*See index for "Compression"—for relation of compression to cylinder head.

Many people who think, because an engine is new or has just been overhauled the timing must be right,—will have a sad awakening if they will only spend a few minutes in verifying the timing.

Most cam shaft gears or fly wheels are marked to insure proper meshing of gears or checking on fly wheel and proper location of the cams. Some times carelessness at the factory in marking this gear may mean that after the first removal of the gear, it will be replaced wrong, because the marking is wrong (see pages 102, 112, 113).

Periods of Time Valves are Usually Open.

Before taking up this subject in detail we shall again review the relation of the speed of crank shaft to cam shaft and get the name of the parts clearly in mind.

A stroke, is the movement of the piston from the top to the bottom, or from the bottom to the top. This motion is called reciprocating motion of piston. When the piston goes from either top to bottom or bottom to top, the crank shaft turns **one-half of a revolution.**

Therefore, **four strokes** of the piston would represent **two revolutions** of the crank shaft.

The cam shaft turns one-half as fast as the crank shaft, because the cam gear is twice the size of the crank shaft gear which drives it.

***The nose of the inlet cam is usually shorter on its length of face than the exhaust cam.** Because the exhaust cam holds the valve open much longer period of time than the inlet cam holds the inlet valve open.

The cams which operate the valves are steel forgings, turned and ground to correct shape. They are then case-hardened to decrease wear, and are usually an integral part of the cam shaft.

The shape of the cam determines the actual lift of the valve and the time during which it shall stay open. Chart 44, page 94, shows how cam contours are plotted and several generally used shapes.

Cams which are pointed give a slow opening and slow closing, the greatest opening being at the middle of the valve lift period.

Cams which are more nearly square, open the valve rapidly, keep it nearly wide open until ready to close and then allow it to close quickly.

It is usual to so design the positioning of the cam shaft and valve tappets that the tappets are not directly over the center of the shaft, but are offset slightly on the lift side. This gives a more direct lift instead of a side thrust as would be the case if they were centered.

In actual practice, the inlet valve seldom opens on top, as shown in chart 26 (page 54) but usually **after** the top of stroke, varying from 5 to 15 degrees as explained in fig. 1, chart 46.

The inlet seldom closes when piston reaches bottom, but from 5 to 38 degrees **after** the bottom. (See fig. 2, chart 46.)

The exhaust valve seldom opens on bottom, but usually 40 to 50 degreees **before** bottom (fig. 3).

The exhaust valve seldom closes on top of stroke, but usually 5 to 10 degrees **after** top. (In fig. 4, chart 46, illustration shows exhaust valve closing on top, in order that reader will more clearly understand the illustration.)

The cam turns the same speed as the cam shaft. The nose on the cam **raises** the valve. Therefore the **inlet** valve will be raised **once** during the four strokes, and the **exhaust** valve will be raised **once** during the four strokes.

---

*A point which suggests itself on the timing of the inlet opening, and which also holds true for other operations on the timing circle, is in the securing of a quiet cam. Quietness in the cams is generally secured at the sacrifice of power. A steep cam is as a rule more noisy and more powerful than one giving a slower opening.

To secure the full opening of the inlet valve at a point which will not be too late to permit a full charge to be taken into the cylinder, and yet at the same time to have a cam which will not be noisy, means that the inlet opening will have to be started fairly early. This is one of the points which often induces a maker to sacrifice the vacuum to some extent for the sake of quietness.

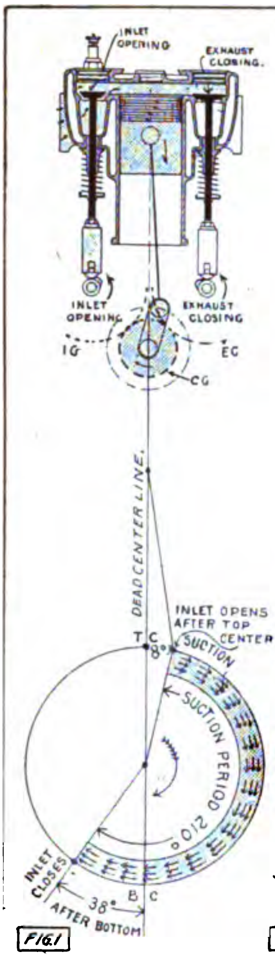


FIG. 1

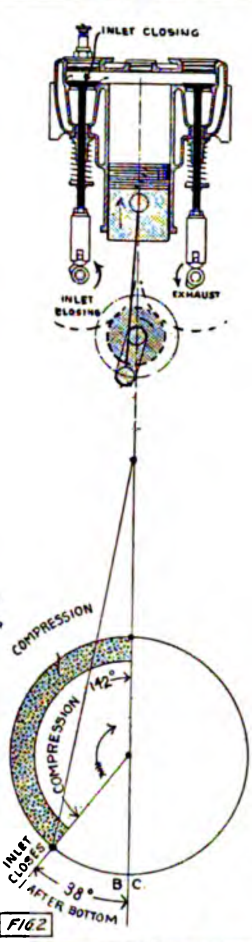


FIG. 2

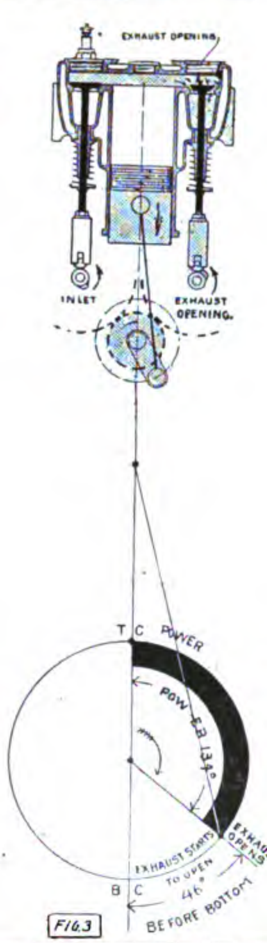


FIG. 3

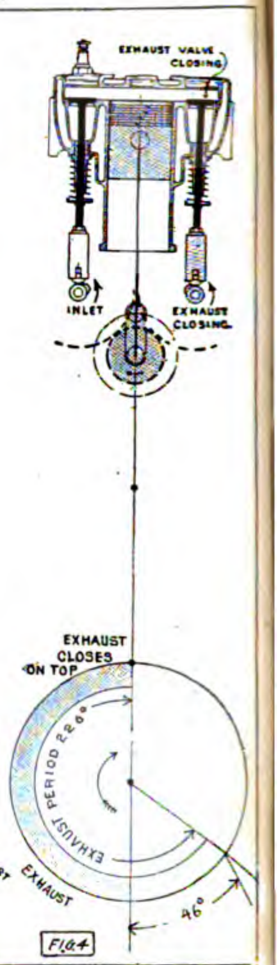


FIG. 4

Example: Inlet opens 8° after top, closes 38° after bottom. Exhaust opens 46° before bottom and closes on top.

Fig. 1: Inlet Valve Starting to Open 8° after top center ("TC") (viewing engine from front); note the inlet will remain open during suction period until crank is 38° after bottom center ("BC"). The period of travel of the crank during suction period is 210°. The inlet valve is open during this period.

Fig. 2: Inlet Valve has Closed and piston will now travel up on compression to top center ("TC"). The period of travel of crank during compression period is 142°.

Fig. 3. The Spark Occurs at Top (in actual practice, just before the top), therefore, the next stroke down will be power stroke. Note the period of travel of crank pin during power stroke is only 134°, as the exhaust valve starts to open at 46° before bottom. Note exhaust cam just starting to open exhaust valve.

Fig. 4: Exhaust Opens 46° before Piston reaches bottom. The Exhaust Valve Remains Open during a period of 226°; crank traveling from 46° before bottom, to bottom, thence to top ("TC"). In this instance the exhaust valve closes on top or dead center. In actual practice it usually closes a little after top dead center, about 7 or 8°.

Observe Position of cams during the various periods. The cam turns ½ the speed of crank shaft, therefore, if crank shaft revolves **twice** to complete the four strokes, then the cams will revolve **one** revolution.

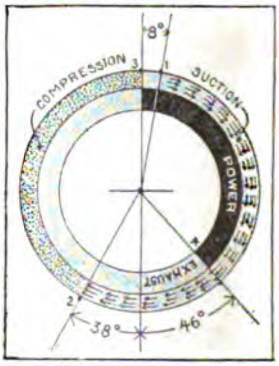


Fig 5, illustrates all the above in one illustration.

CHART NO. 46—Explanation of Period of Suction, Compression, Explosion, Power and Exhaust. (View from front of Engine.)

Chart 45 on page 93.

By referring to fig. 5, chart 29 (page 58), note inlet cam on first stroke will be in position of (1), and will turn from 1 to 2, or 90 degrees during the first stroke.

Exhaust cam will be in position (2) and will turn from 2 to 3, or 90 degrees during the first stroke.

During each stroke the cam moves 90 degrees, whereas the crank moves 180 degrees.

Inasmuch as a stroke of the piston is from top to bottom, or 180 degrees travel of crank, it will then be necessary to distinguish the difference between the time of opening and closing of valves and the period of travel of the crank shaft during the four actions of suction, compression, explosion and exhaust periods. (See chart 46).

Meaning of Valve Lap.

The word "lap" is used often in connection with valve timing, also firing order of cylinders.

In speaking of firing order of cylinders we speak of one cylinder "lapping" another, for instance, on a certain eight cylinder engine there are eight periods of 44 degrees travel of crank when two cylinders are on power, or "lapping" at the same time.

In using the word "lap" in connection with valve timing, it means the period of time that both valves are open at the same time, or + (plus lap).

We will divide the laps into "zero lap,"—(minus) lap, and + (plus) lap.

Zero lap: If the exhaust valve closed just as the inlet valve started to open, we will term this, "zero lap" (no lap at all).

The "zero lap" means exhaust closes at the same time the inlet valve opens. With zero lap there is no vacuum in the cylinder at time of inlet valve opening.

Minus lap: If the exhaust valve closed before the inlet valve opens; this we will call "minus lap," designated with a (—) mark.

The "— minus lap," which is the general condition used on most engines, the exhaust closes an appreciable period before the inlet opens. This permits the piston to descend slightly on the suction stroke before the inlet valve opens, thus creating a vacuum in the combustion space. Therefore, the rush of gases into cylinder is greater, due to this partial vacuum.

By referring to fig. 1, chart 29, note exhaust valve closed before the inlet starts to open; this would be termed "— minus lap."

Plus lap: If the inlet valve opened before the exhaust valve closed; this we will call "plus lap," designated with a + mark.

The "+ lap," means that both exhaust and inlet valve are open together for a period of the lap. In other words the inlet opens before the exhaust closes. The theory is that the inertia or rush of exhaust gases passing out the exhaust port is sufficiently great to create a partial vacuum, and causes a stronger in-rush of fresh gas.

Owing to the fact that the exhaust and inlet gases should not conflict in their direction, the + plus lap is generally used on "T" head engines.

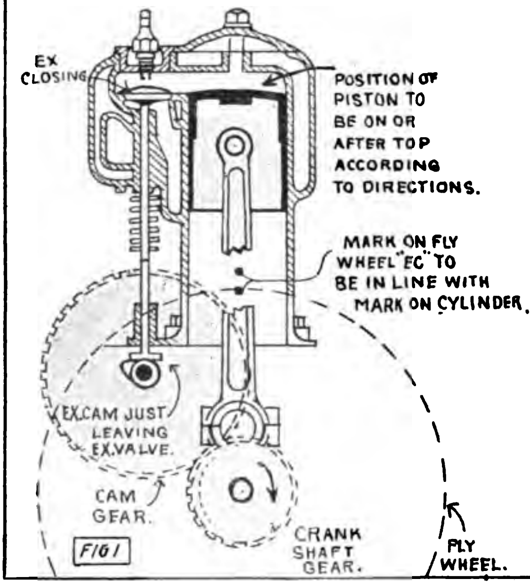
See page 114 and note the average valve timing of various engines. Compare the inlet valve opening and exhaust closing.

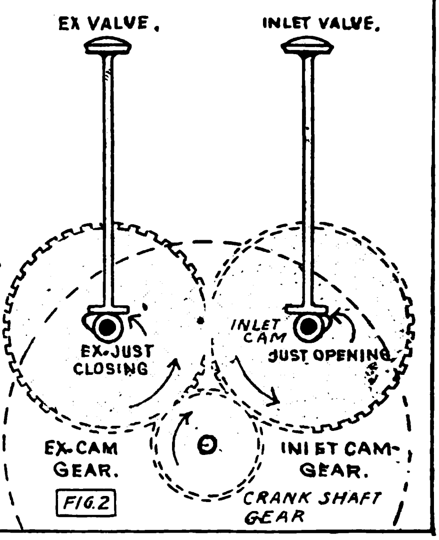
Valve "Lag" and Valve "Lead."

If a valve opens late or remains open after it is supposed to close, it is said to "lag." For instance, the exhaust valve is usually allowed to "lag" about 10 degrees after leaving top of its exhaust stroke before it closes.

Valve "lead" usually applies to the valve opening before piston reaches top or bottom center, this distance is called "lead;" if it closes after center, this distance is termed "lag."

For instance, the setting of spark is sometimes given a "lead" or the exhaust valve is usually given a lead of 46 degrees, meaning opening before


EX CLOSING
POSITION OF PISTON TO BE ON OR AFTER TOP ACCORDING TO DIRECTIONS.
MARK ON FLY WHEEL "EC" TO BE IN LINE WITH MARK ON CYLINDER.
EX.CAM JUST LEAVING EX.VALVE.
CAM GEAR.
FIG 1
CRANK SHAFT GEAR.
FLY WHEEL.



View from front of engine. Below the view is from the rear.

Fig. 1.—To set the cam for valve opening on an "L" head cylinder it is only necessary to set the one cam, which is the exhaust cam—at the closing point. If engine has a multiple of cylinders all other cams will then operate as they should; as all exhaust and all inlet cams are on the one cam shaft and are set permanently when cam shaft is made.

Fig. 2.—When setting valves on a "T" head cylinder engine, there are two cams to set; the inlet and the exhaust. If cylinder is a four or six, or any multiple of cylinders; by setting the cam on the first, or say, No. 1 cylinder—is all that is necessary.

The usual plan is to set the exhaust as it is just closing, and the inlet as it is just opening.

On a "T" head, all exhaust cams are on the exhaust cam shaft and all inlet cams are on the inlet cam shaft.

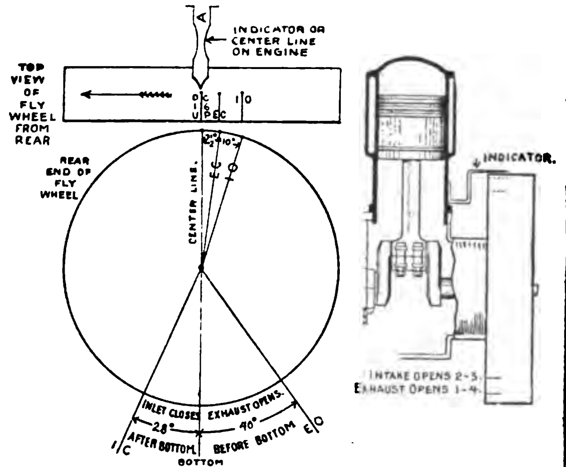


Fig. 3. Example of setting by "indicator."

Example of Valve Timing.

Example, set valves as follows; exhaust closes 2½° after top, inlet opens 10° after top.

There are usually marks on the face of fly wheel, which indicate the position for placing the crank shaft when setting the cams.

For instance; when piston of No. 1 and No. 4 or 1 and 6, cylinders are on top of stroke, a line will often be made on fly wheel which is supposed to line up with a mark on the cylinder, or on "indicator" placed on lower part of rear cylinder.

This line will read "DC 1-4 UP" (if 4 cylinder engine), meaning "1 and 4 are on dead center-up" (or "DC 1-6 UP," if a six cylinder).

If exhaust closed 2½° after upper dead center, then a mark would appear on fly wheel 2½° further away from the center mark (standing in rear of fly wheel).

If inlet opened 10° after dead center, then another mark would appear as shown.

To then set the valve on "L" head engine, first place No. 1 piston on dead center (D C), then move fly wheel to left 2½° to "E C" (exhaust closing), and set exhaust cam at the closing point.

To set "T" head, first place No. 1 piston on dead center with "D C" line, in line with "indicator," then move fly wheel to left to "E C"—set exhaust valve closing.

Next, move fly wheel still further to "I O" (inlet opening), and set inlet cam at opening point. Mesh the gears and valves are timed.

Timing valves on a round or "I" head cylinder with valves overhead, the procedure is the same as in the "L" unless valves are on opposite side, as on a "T" head.

CHART NO. 47—Timing Valves on a "T & L" Head Cylinder Engine. Example of Fly Wheel Marking.

Note: An indicator is also termed a "trammel."

bottom. The faster engines are designed to run, the greater the amount of "lead" or "advance" given the opening of the exhaust, also the spark when running.

Valve Timing Position.

The position of the crank shaft determines the position of the piston.

The position of the piston determines the point where valve is set to open or close.

Therefore the cam shaft must be so placed, that the cam will raise the valve when piston is at a certain position.

*This is **accomplished by meshing the cam gear with crank shaft gear** when piston is in correct position.

Marks are usually placed by the manufacturer on the cam gears which will indicate just where to mesh gears (see page 106). The fly wheel is seldom used for timing unless there are no marks on gears or if it is desirable **to check the valve timing.**

It is also important to secure the proper valve clearance as per pages 94 and 95, before timing the valve.

Setting Valves on a Single Cylinder Engine.

For instance; suppose the valves are to be set on a single cylinder "T" head engine with exhaust to close on dead center, and inlet to open one-eighth inch after top on suction stroke.

Setting exhaust valve: first; place piston (by turning crank shaft) on dead center, then mesh exhaust cam gear with crank shaft gear, so that exhaust valve is just seating. (See fig. 1, chart 46.) **Setting inlet valve**: move piston down one-eighth of an inch from top, mesh inlet cam gear with crank shaft gear.

It will be noted that the inlet opens and suction stroke begins right after exhaust closes. Therefore the closing of the exhaust and opening of the intake is the point to work from.

A matter of importance to remember, is **the spark.** When setting valves, be sure the contact on timer or magneto is set to occur when piston is on top of compression stroke, a full revolution from where inlet valve starts to open. (This will be treated under ignition timing.)

Also remember to first get the "valve clearance" or "air gap" correct as per pages 94 and 95.

Setting the Valves on a Multiple Cylinder Engine.

Setting the valves on a multiple cylinder engine is identically the same operation as timing a single cylinder engine

†If there are a multiple of cylinders, say four, then there must be at least one inlet and one exhaust valve for each cylinder. Therefore, there must be four cams for the four inlet valves and four cams for the four exhaust valves.

If engine cylinders are "T" head, then there are **two cam shafts**; one for the inlet valves and one for the exhaust valves, placed on opposite sides of the cylinders.

If cylinders are "L" or "round" head with valves in the head, then there is but **one cam shaft.** (See chart 40, page 86). (On some 8 and twin six engines however, there are two cam shafts.)

---

†In some of the late makes, each cylinder has 4 valves, two inlet and two exhaust.

*Sometimes reversing the crank shaft gear will give better results, due to key-way being slightly offset.

It is well to note that even though there are four cylinders, six, eight or twelve cylinders, each of the pistons must pass through the four strokes during two revolutions of the crank shaft, even though two of the cylinders are firing at once during part of the time (which they are in a six, eight and twelve cylinder engine).

Just how these four strokes are made by each piston during two revolutions of the crank, is explained under "firing order," instruction No. 10.

We will next take up the method of setting the cams, so they will open and close the valves at the correct time.

If a **four cylinder** engine, remember that owing to the shape of crank shaft, pistons 1 and 4 are always up or in line, when 2 and 3 are down, or vice-versa (see page 116). If a **six cylinder** engine, pistons, 1 and 6 are in line, 3 and 4, and 2 and 5 (see chart 55).

If cylinders are "L" type or "round" type, with all valves on one side, then it is only necessary to **set the one cam shaft,** and do the timing from one cylinder, usually the front one, see fig. 1, chart 47, page 102.

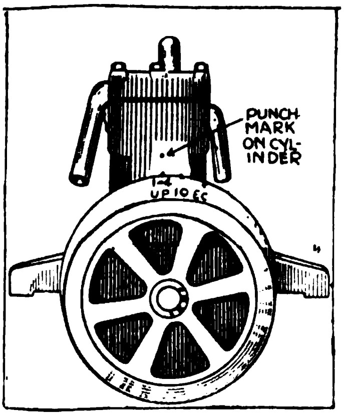
If cylinders are "T" type, then it will be necessary to **set the inlet cam shaft and the exhaust cam shaft separately,** but it is necessary only to set valves in one cylinder, as the other cams are fastened permanently on the cam shaft, and must open and close all other valves at the correct time. See fig. 2, chart 47.

Therefore the **cams do not need to be set on the shaft,** but by meshing the cam gear in front of the engine with the drive gear, the position of the nose of the cams can be adjusted. **The usual plan** is to place piston of No. 1 cylinder at the top of its stroke, and work from that point.

An eight cylinder engine, usually employs one cam shaft with 8 or 16 cams. The Cole has 16 cams, one for each valve whereas the Cadillac has eight cams.

To set the valves of the Cole engine, place piston of No. 1 cylinder on top dead center, then turn fly wheel in direction of rotation say 10°, to where the **exhaust is supposed to close,** at this point mesh the exhaust cam gear so exhaust valve is just closing, or cam is just leaving the end of valve. Either side can be timed, which will suffice for both sides or sets of cylinders. Usually the right side is timed.

†Timing Marks on Fly Wheel.



The usual plan to time valves or set in correct time with cam shaft, is to mesh the cam gears with point marked thereon to correspond with the mark on crank shaft gear at the time No. 1 cylinder is on top of its stroke.

Usually marks also appear on the circumference surface of the fly wheel, which indicate position crank shaft is to be placed for correct setting of valves.

The mark on fly wheel is placed in line with a center mark on cylinder or elsewhere.

If there are no marks on gears or fly wheel, then it will be necessary to first determine where you wish to set the valves.

---

*Note—Always adjust valve clearance before proceeding to set valve, see chart 44.

See Dyke's 4 and 6 cylinder engine models.

†By referring to inserts and page 120 an "inspection hole" will be noticed in housing over fly wheel for observing marks on fly wheel.

Timing "T" Head Cylinder Engine Valves.

Although fly wheels and cam gears are usually marked and the setting done with gears, the explanation will show how to check the valve timing and mark fly wheel if necessary.

For instance, suppose engine was a "T" head **four cylinder** type of engine, and you wished to time the valves as follows: Exhaust to close 15° past upper dead center. Inlet to open 8° past upper dead center. (This is an unusual timing.)

In actual timing this is really all that is necessary to know, as the other points of closing and opening will be taken care of by the other cams on cam shaft.

***Procedure of marking fly wheel**: (Refer to illustration.) Place No. 1 piston on top or upper dead center. Mark a center mark on cylinder, (usually on **indicator** or what is called a "**trammel**" is placed at this point, see fig. 3, page 102). Now mark a line on face of fly wheel and mark on this line "**1-4 UP,**" meaning pistons **1 and 4 are on upper (or top) dead center.**

†Now measure 8 degrees from this line to the **right** and make another mark on fly wheel—mark it "**IO.**" meaning **inlet opens.**

Now mark another line 15 degrees from the DC line, to the **right** on fly wheel—mark this "**EC,**" meaning **exhaust closes.**

Next, turn fly wheel slightly until line marked "**EC**" is in line with indicator or punch mark on cylinder. At this point piston is 15° down (measured on fly wheel) in direction of rotation from top. Note that **you are supposed to be in rear of fly wheel.**

Setting exhaust cam; take exhaust cam gear out of mesh with crank shaft gear (if a gear, or if a chain loosen chain); turn exhaust cam in direction of rotation (note direction it turns, fig. 2, page 102, opposite that of crank shaft); place exhaust cam at closing point (see chart 47, fig. 2). Now mesh exhaust cam gear and exhaust valves are timed.

Setting inlet cam, next, turn fly wheel **to** left until line "IO" is in line with center mark or indicator on cylinder;at this point piston is 8° down (measured on fly wheel in direction of rotation from top). Take inlet cam gear out of mesh and turn inlet cam in direction of rotation until it is just at the point of opening (see fig 2, page 102). Mesh gears and inlet valves are timed.

Next adjust the "air gap" or "valve clearance," as per pages 94 and 95.

Timing the Valves on "L" Head Type of Engine.

Only one cam shaft need be set when all valves are on one side, and all cams on one cam shaft, see fig. 1, chart 47.

The usual plan is to place position of No. 1 piston at point where **exhaust valve is to be closed,** and mesh the exhaust cam shaft gear at this point.

Timing Valves on an "I" or Round Head Type of Engine.

The overhead valves are usually operated by push rods. All from one side of engine and from one cam shaft, therefore the timing would be the same as an "L" head.

If overhead cam shaft; the valves are usually operated by one cam shaft, therefore the principle is the same, see chart 66, page 137.

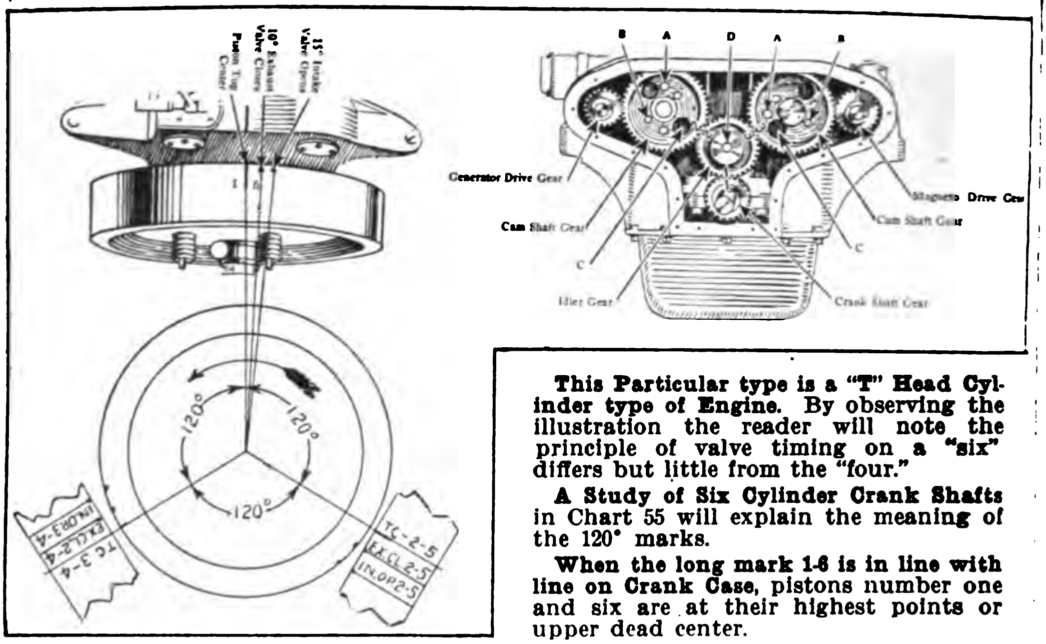
It is important to adjust the "air gap" or "valve clearance."

---

*A study of fig. 3, page 102, of the six cylinder timing will assist you in understanding this.

†See page 115, how to convert degrees into inches or fraction thereof, or just how far in inches to make the mark on different diameter fly wheels.

‡To find position of piston, see index "finding position of the piston."



This Particular type is a "T" Head Cylinder type of Engine. By observing the illustration the reader will note the principle of valve timing on a "six" differs but little from the "four."

A Study of Six Cylinder Crank Shafts in Chart 55 will explain the meaning of the 120° marks.

When the long mark 1-6 is in line with line on Crank Case, pistons number one and six are at their highest points or upper dead center.

When mark 2-5 is in line, pistons number two and five are on upper dead center.

When mark 3-4 is in line, pistons three and four are on upper dead center.

From Upper Dead Center, pistons are ready to start downward on their intake or power stroke as the case may be.

If the Piston of any Particular Cylinder is Ready to Start on its intake stroke, then when the first punch mark from center mark, or 10° of the complete circle is in line with mark on crank case, the exhaust valve of this particular cylinder has just closed.

When the Second Punch mark or 15° is in line, intake valve of this particular cylinder begins to open.

No Reference is made here as to closing of Intake and opening of Exhaust, because it is of no particular advantage when timing valves, as the opening of inlet and closing of exhaust is all that is necessary to know.

The only Points to Determine is when the inlet opens and exhaust closes and set as shown above.

To Remove Timing Gears on the Mitchell. Note there are two cam shafts ("T" head cylinders.) To remove idler gear screw out hexagon headed bolt "D," which has a left-hand thread, from idler gear shaft.

To remove Cam Shaft Gears. Remove hexagon bolts "A" and hexagon nuts "B." The gear now comes off its hub.

To Adjust Mesh of Timing Gears. Through holes "C" of cam shaft gears loosen the bolts that hold bearings to crank case. Bearings being eccentric they can be turned until desired mesh of gears is obtained. No further adjustments of the other cam shaft bearings are necessary to make this adjustment. Be sure bolts are again drawn up tight after adjustments are made.

To Adjust Mesh of Magneto Shaft Gear. Loosen the three bolts tnat hold bearing to crank case; bearing being an eccentric can be turned until the desired mesh is obtained.

To Adjust Generator Drive Shaft Gear. Loosen the three bolts that hold bearing to crank case and proceed same as to adjust magneto drive shaft gear.

HOW TO MESH TIMING GEARS; by removing forward end of crank case cover, gears can be inspected. The gears should be so set that the figure 1 stamped on crank shaft gear should match with figure 1 stamped on idler gear; mark 2 on idler should match with mark 2 on cam shaft gear and mark 3 on idler gear should match with mark 3 on other cam shaft gear.

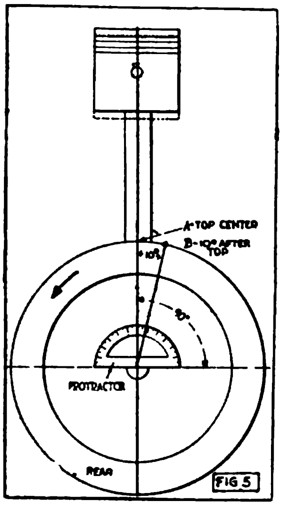
This Principle of removing and meshing gears is common practice.

CHART NO. 47A—Valve Timing Marks of a Six Cylinder Engine. Meshing of Timing Gears on a "T" head Engine (Mitchell early model 6-16).

Note—The later Mitchell timing is given in "Standard Adjustments of Leading Cars" and is an "L" head type engine.

Method of Marking a Fly Wheel in Degrees.

Although a scale is worked out on page 115 to find in inches or a fraction thereof just where to mark fly wheel in degrees, another method is given below. Suppose there are no timing marks on fly wheel and you desire to mark same.



Set the engine so that the piston in No. 1 cylinder, namely the cylinder nearest the radiator, is at the top of its stroke. With the use of the protractor or with a square, make a mark at A on the rim of the flywheel, on the inner edge, which mark will be directly above the center of the crank shaft or piston is at top of its stroke.

Then, with the protractor placed against the fly wheel so that the 90 degrees mark points directly toward mark A, go 10 degrees to the right on the protractor (standing in rear of engine), then make a mark at B on the fly wheel. This mark will be 10 degrees to the right of mark A. Now turn the fly wheel until mark B is at top center.

With the engine in this position mesh the timing gears so that the exhaust valve of No. 1 cylinder is just closing.

It is understood that when standing behind fly wheel it would turn to the left or as per arrow point. Therefore, piston must first reach top center (A) with exhaust valve still open, and travel 10 degrees further to (B) before it closes.

Variation of Valve Timing Marks—on fly wheel.

Sometimes the marks may vary, for instance, instead of "1-4 UP" or "1-4 DC," it may appear as, "T C 1-4" (top center 1-4) or "U C 1-4" (meaning upper dead center), or some similar mark meaning the same thing.

Some manufacturers vary their marking on the rim of the fly wheel as **follows:** Inlet opens "IN-O" or "I. O." Inlet closes "IN-C" or "I. C."

Exhaust opens "EX-O" or "E. O." or "X. O." Exhaust closes "EX-C" or "E. C." or "X. C."

If the figures 1-4 or 2-3 appear after or before the above marks, as "1-4-IO.," this means the number of the cylinders, as "1 and 4, inlet opens."

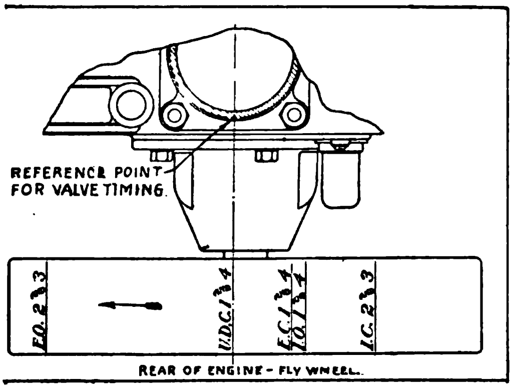


Fig. 1.—Valve timing marks on fly wheel of a Reo four cylinder engine.

For an example of valve timing marks on a four cylinder engine fly wheel, see fig. 1—the engine fly wheel has upon its face, the following marks:

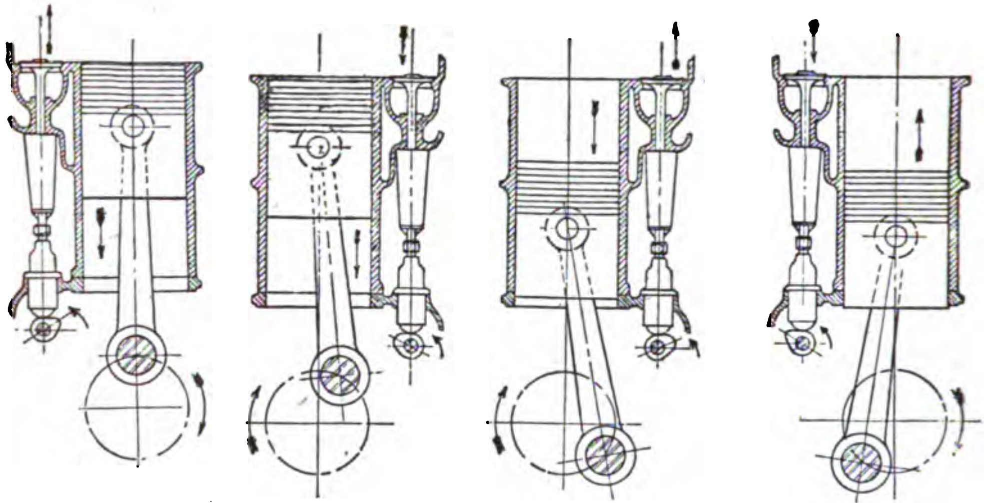
I. O., meaning, inlet valve opens.
I. C., meaning, inlet valve closes.
E. O., meaning, exhaust valve opens.
E. C., meaning exhaust valve closes.

U.D.C., 1 and 4, upper dead center; cylinder 1 and 4.

U.D.C., 2 and 3, upper dead center; cylinder 2 and 3.

These points, marked upon the face of the wheel, show where the exhaust and inlet valves of each cylinder should open and close. Taking as a reference point the small boss marked with a cross upon cylinder No. 4, next to dash, this being plainly shown in the illustration, together with the marking on one side of the fly wheel.

The engine cylinders are numbered 1, 2, 3 and 4. No. 1 being next to radiator, and No. 4 next to dash. By referring to pages 76 and 78 of crank shafts, previously given, it will be seen that cranks 2 and 3, and 1 and 4 are exactly 180 degrees apart. Therefore, the same marking on the fly wheel that serves for No. 2, also serves for No. 3, and the marking for No. 1 serves for No. 4, these points being exactly one-half revolution, or 180 degrees apart, as before mentioned.



2

3

4

1. **Inlet Opens.**	2. **Exhaust Closes.**	**Fig. 3. Exhaust Opens.**	**Fig. 4. Inlet Closes.**
Top Center	⅛" Past Top Center	"38"; ¾" Before Bottom Center	⅝" Past Bottom Center
Top Center	⅛" Past Top Center	"48" 1" Before Bottom Center	¾" Past Bottom Center

Figures 1, 2, 3 and 4 illustrate the valve timing of the Locomobile "38" and "48" six cylinder engine. The timing being given in inches. The top line is the timing of the model "38" and the lower line "48." **First,** adjust the valve clearance by adjusting check nut on valve lifter or plunger until it just touches the bottom of the valve stem. The cam is then off the bottom of the plunger and piston No. 1 is on the top of stroke. This will give about .005 of an inch clearance. **Next;** the intake valve is set to open at the top of the stroke, therefore set the inlet cam just starting to open the inlet valve at this point. **Next;** set the exhaust valve at point just closing, when piston is down ⅛ of an inch from top.

Cadillac valve timing: Open cylinder relief cocks, turn engine until valve you are timing (say exhaust of No. 1 right) has just seated. Turn still farther, until line marked "**Ex.** | **S.**" on fly wheel, is under trammel on crank case. The cam is then in correct position for that valve.

To check inlet valve—the same procedure, but mark on fly wheel is "**In** | **S.**" (inlet seated.)

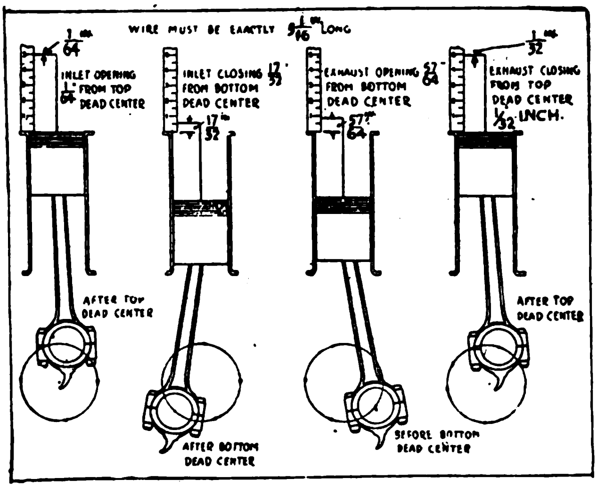

WIRE MUST BE EXACTLY 9 1/16 IN. LONG
1/64 IN.
INLET OPENING 1/64" FROM TOP DEAD CENTER
AFTER TOP DEAD CENTER
INLET CLOSING 17/32" FROM BOTTOM DEAD CENTER
17/32 IN.
AFTER BOTTOM DEAD CENTER
EXHAUST OPENING 57/64" FROM BOTTOM DEAD CENTER
57/64 IN.
BEFORE BOTTOM DEAD CENTER
1/32 IN.
EXHAUST CLOSING FROM TOP DEAD CENTER 1/32 INCH.
AFTER TOP DEAD CENTER

Fig. 3.—The timing of the Hudson Super Six measured according to piston travel: Intake opens $1/64$ after top dead center; closes $17/32$ after bottom dead center; exhaust opens $57/64$ before bottom dead center; closes $1/32$ after top dead center.

These measurements are best for timing, but for comparison with other engines it is better to state the valve movement in degrees: Intake opens 7 deg. after top dead center; closes approximately 42 deg. after lower dead center; exhaust opens about 55 deg. before dead center; closes 8 deg. after top dead center.

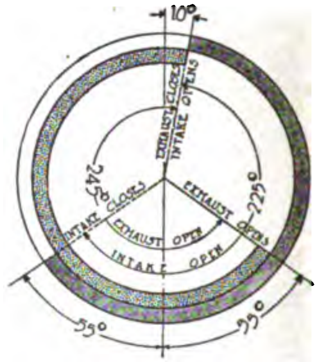


Fig. 6.—Valve timing diagram of the Stutz racing engine explained on page 109.

The Stutz (see diagram above) the **exhaust opens** 55° before bottom and closes 10° after top. **Inlet opens** 10° after top, **closes** 55° after bottom.

Dusenberg racer engine: Ex. opens, 46° before bottom, closes 8° after top. **Inlet opens** 4° after top, **closes** 42° after bottom.

The Maxwell racer engine: Ex. opens 69° before bottom, closes 13° 45′ after top. **Inlet opens** top of dead center, **closes** 32° after bottom.

A prominent French racing engine uses a valve timing of—Inlet opens 10-12° after top, closes 45° after bottom. Exhaust opens 45° and closes 18° after top.

CHART NO. 48—Example of Valve Timing in Inches. Valve Timing of Racing Engines. (See "Standard Adjustment of Leading Cars," page 543.)

page 500 for Locomobile gear shift and page 362 for electric system.

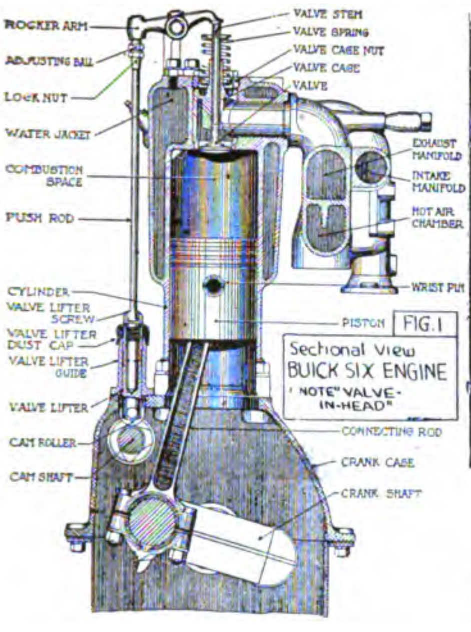


FIG. 1

Sectional View BUICK SIX ENGINE "NOTE" VALVE-IN-HEAD"

The Buick valves, both inlet and exhaust are placed in the head of cylinder. The valves are in cages and can be ground by lifting push rod out of socket in valve lifter and loosening valve cage nuts and unscrewing valve cage. The valve cage can also be ground to its seat as per page 742 and 688.

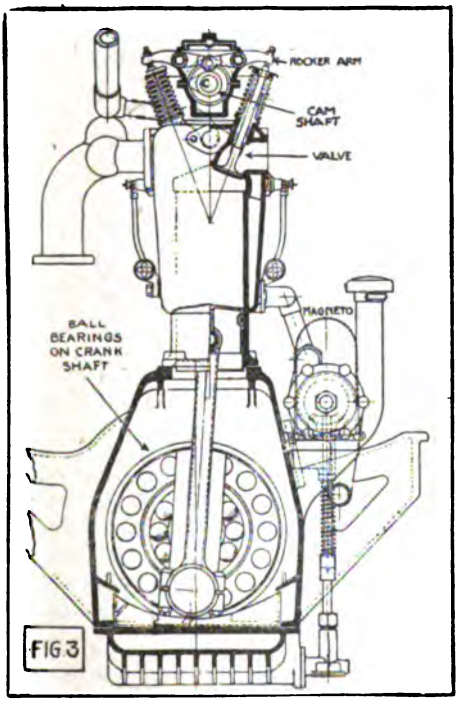


FIG 3

The Stutz racing engine with two inlet and two exhaust valves to each cylinder (4 cylinders). Valves are operated by an overhead cam shaft. See page 108 for valve timing.

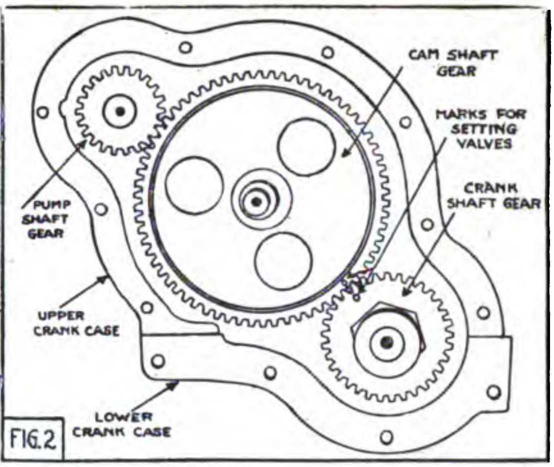


FIG. 2

Timing Buick Overhead Valves.

The overhead valves can be timed in just the same manner as timing the valves when placed on the side as described on page 102, but in order to simplify the work, quite often, **manufacturers mark the timing gears as described in the illustration fig. 2.**

Timing the valves: For instance, to time the valves of the six cylinder Buick; the cam shaft gear which is marked "O" corresponds with the tooth on the crank shaft gear as shown in fig. 2.

Adjusting push rod clearance: Turn the engine by hand (in a clockwise direction, looking at it from in front), until the line marked "1 and 6," on the fly wheel, comes opposite the line on the rim of the inspection hole. This is the firing position for cylinders Nos. 1 and 6, numbering from the radiator back, and one or the other of these cylinders will be found to have both valves closed, so that both rocker arms will have a slight amount of play. The push rods should then be adjusted so as to have .005 inch clearance between the end of the valve stem and the rocker arm. This is approximately the thickness of a sheet of heavy paper or very light card, and is sufficient to allow for the expansion of the push rod when the motor gets warm. Push rods for the other cylinders may be adjusted in the same manner.

Setting the ignition on Buick: Turn engine clockwise, as before, until "1 and 6" line on fly wheel comes in view; continue turning slowly until line marked "7°" registers with indicator mark (which is approximately 1 inch after dead center mark). **This is the point to set ignition timer. Retard spark. Set breaker cam on timer, so lobe of cam is just commencing to separate contact points. Firing order is 1, 4, 2, 6, 3, 5.**

The Stutz Racing Engine —16 Valves.

An end view is shown. A brief detail of the specifications are as follows:

General: Bore, 3 13-16 inches; stroke, 6½ inches. Cubic inch displacement of all cylinders, of which there are 4, is 296.81 cubic inches, or 74.2 cubic inches per h. p.

The maximum power is obtained at a piston speed of 3250 feet per minute which corresponds to 3000 r. p. m. and is about 130 h. p.

Valves: there are two inlet and two exhaust valves for each cylinder which is termed "dual" valves. The **valves are operated by an overhead cam shaft, which** is operated by a chain of gears from the crank shaft gear.

Where four valves are used to each cylinder, they are known as "dual valves," see page 927.

The crank shaft is ball bearing with one inch balls.

CHART NO. 49—Timing the Valves when placed Overhead and operated by Rocker Arm. A Timing the Ignition. The Six Cylinder Buick as an example. **The Stutz Racing Engine.**

Chart 50 omitted, error in numbering.

Checking the Valve Timing.

The purpose of checking the valves is to see if they are opening and closing as marked on fly wheel.

Although it is only necessary to set the exhaust cam so exhaust valve will just close, on an "L" type of cylinder engine, there are other marks which are used for checking the timing.

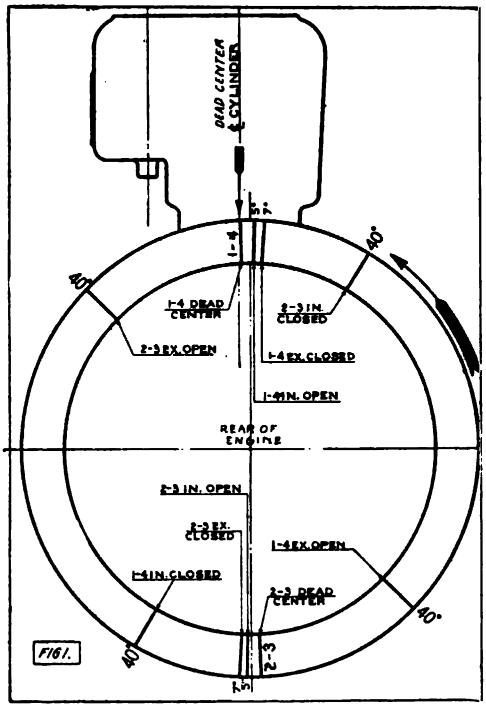


Fig. 2.—An example of valve timing marks on the fly wheel of a four cylinder engine. See text for checking valve timing from these marks. View from rear of engine. Note it turns to the left.

As an example a four cylinder engine is used, with timing scale as follows:

Dead center of cylinders 1 and 4 are marked on fly wheel "1-4."

Dead center of cylinders 2 and 3 are marked on fly wheel "2-3."

Inlet valve opens 5° past top center marked on fly wheel "1-4 IN. O."

Inlet valve closes 40° past bottom center marked on fly wheel "1-4 IN. C."

Exhaust valve opens 40° before bottom center marked on fly wheel "1-4 EX. O."

Exhaust valve closes 7° past top center marked on fly wheel "1-4 EX. C."

Note—the marking on illustration is merely 5° and 7°, the reading at end of arrow lines indicate the meaning.

The same marks appear for cylinders 2 and 3.

The lines on fly wheel indicate the points at which the valves open and close.

When fly wheel is turned so that the line marked "1-4" is up in line with mark on cylinder—No. 1 and 4 pistons are just at the uppermost points of their strokes or at "upper dead center." When line "2-3" is up in line with center mark on cylinder the No. 2 and 3 pistons are at upper dead center.

To determine whether or not the valves are properly timed, first open the relief cocks on top of the cylinders, then have some one crank the engine over slowly until the line marked "1-4" is opposite the center line of the cylinders. At this point the exhaust valve in **either** No. 1 or No. 4 cylinder should be just closed.

If you find that the exhaust valve in No. 4 cylinder is beginning to close and you wish to check up the valve timing in No. 1 cylinder, turn the fly wheel around to the **left** (standing in rear of engine), one complete revolution, until line "1-4" is again brought opposite the center line of the cylinder; then continue slowly turning the fly wheel about three-quarters of an inch farther to the left until the line marked "7° EX. C." coincides with the center line of the cylinders. This is the point at which the **exhaust valve in the No. 1 cylinder should just seat itself or close.**

†**To determine whether or not the valve is seated,** see if tappet or push rod underneath the valve can be turned with the fingers. If the tappet turns freely, the valve is seated, but if the tappet is hard to turn, that will show that the valve is still being held slightly open. If this is the case, loosen the lock nut on the tappet screw, and turn the screw down until the valve has the proper clearance, then turn the lock nut down tight against the tappet.

When the valves are closed there should be clearance between the end of the valve stems and the tappet screws, of from .003 to .005 of an inch. This amount of clearance is necessary to allow the valve to seat tightly (see page 95).

---

†The opening and closing time of a valve is not when the lifter begins to rise or comes to rest but when it makes or leaves contact—see page 94, figs. 2 and 3.

To check up the timing of the inlet valve in No. 1 cylinder, turn the fly wheel slightly to the **right** until the line "1-4" is in line with the center of the cylinders, and then turn the fly wheel about one-half an inch to the **left** until the line marked "5° **IN. O.**" coincides with the center line of the cylinder. At this point the **inlet valve should just begin to open.**

Continue turning the fly wheel half a turn to the **left,** stopping when the line marked "**40° IN. C,**" just to the *right of the line "2-3" comes in line with center of the cylinders. At this point the **inlet valve should just close.**

To see if the exhaust valve in No. 1 cylinder opens at the proper time, revolve the fly wheel still farther to the **left,** and stop when the line "**40° EX. O,**" which is the first line to the *left of the "2-3" center line, comes up in line with center of the cylinders. This is the point where the **exhaust valve in No. 1 cylinder should just begin to open.** The above operation completes the **checking** of cylinder No. 1.

‡**To check the timing of cylinder No. 2,** turn the fly wheel until the line marked "2-3" is in line with the center line of the cylinders. If the exhaust valve in the No. 2 cylinder is closed, turn the fly wheel through one complete revolution, until the line "2-3" is up again; the exhaust valve in No. 2 cylinder should then be just starting to close. Proceed now the same as in timing the No. 1 cylinder. The valves in cylinders No. 3 and No. 4 are timed in the same manner.

Cylinders No. 1 and 4 are timed from the center line "1-4"; 5° to left for inlet opening and 7° for exhaust closing, and cylinders No. 2 and 3 from the line "2-3;" 5° to left for inlet opening and 7° for exhaust closing.

It is advisable, when checking the opening and closing points of the valves with the marks on the fly wheel, to make a note of the variation of each of the valves from the marks in the fly wheel.

Then, after all the valves have been checked you can compare the variations for the different valves and in this way determine whether the variations are due to **the large time gear on the end of the cam shaft not being properly set** with relation to the timing gear on the end of the crank-shaft, **or to wear** in any particular cam or valve tappet. A variation, not to exceed one-half of an inch either way from the lines on the fly wheel, is permissible, and will not make any material difference in the timing of the valves. If the variations exceed this and are uniform for the different valves the correction should be made by re-setting the cam shaft gear. (See "setting of timing gears," this page.)

When the valves are closed there should be clearance between the end of the valve stems and tappet screws, of from .003 to .005 of an inch. This amount of clearance is required to allow the valves to seat tightly. (See "valve clearance," pages 94 and 95.)

The Timing Gears.

Since the position of the cam shaft is always the same with reference to the pistons (because the cam shaft is always in mesh with the crank shaft gear), and since the cams are all integral parts of the shaft, the valve timing cannot change. If the gears are ever removed, they may be put back in the proper position by seeing that the marks on the edges of the teeth "dovetail" together.

If the timing of the valves of an engine is not correct, it is then necessary to re-mesh or re-set the timing gears. It will be necessary to place piston of No. 1 cylinder at top of its stroke. Then remove the gear cover and turn **crank** until the "EX. C" (exhaust closing mark of cylinder No. 1) is in line **with** center mark on ‡cylinder (in rear). Now remove the cam gear from its **shaft** and turn cam shaft in its direction of rotation (it is opposite from direction of rotation of crank shaft), until the **exhaust** valve on cylinder No. 1 is **just closing,** keep the cam shaft in this position, replace the cam gear (large one) on the end of the cam shaft properly meshing it with the gear on the **crank shaft.**

---

‡On engines with unit power plants the center line instead of being on cylinder, a small hole at top of fly wheel case is provided so line and figures on fly wheel can be seen through hole, see page 120.

†The opening and closing time of a valve is not when the lifter begins to rise or comes to rest, but when it makes or leaves contact—see page 94.

*When "2-8" fly wheel mark is at top this marking would be at the right of 2-3. Below, as it is now in illustration, it is to the left.

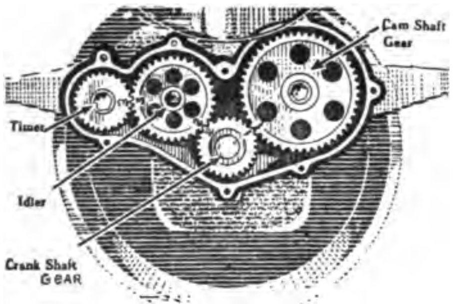


Fig. 1.—Note meshing of crank shaft gear mark (1) between the two teeth on cam shaft gear mark (1). This is the Overland model 85. Note the cam shaft turns in opposite direction to crank shaft when the crank shaft gear drives the cam shaft gear without using an idler gear.

When the gears are originally installed at the factory, there are usually marks stamped on the small crank shaft gear, for instance, a letter "O" or "C," or figures 1 or 2,**and a similar mark is stamped between the two teeth of the larger cam gear** with which it meshes. At this point the valves are supposed to be correctly timed.

If you find that the marked teeth do not come together; do not jump at the conclusion that the gears are improperly set, but first verify the setting by checking the timing of the valves with marks on the fly wheel.

Remarks on the Relation of Timing Gears to Valve Timing.

After your engine has been overhauled a few times the cam shaft gear will have developed a dozen or more meshing marks; each workman having added a few marks that may or may not be right and changed a few that were right until finally it is hopeless to match any of them.

This need not seriously inconvenience you, for if you understand valve timing, you can forget the gear marks and work entirely from the fly wheel marks.

A "trammel" is a stationary starting point to base all your work from (see fig. 3, page 102). The trammel generally is directly over or in front of the fly wheel, but may be located elsewhere if some careless workman has removed your fly wheel and replaced it in a different position (flange connection or a new fly wheel with key in wrong place); the trammel should be shifted until it registers properly when the cylinder indicated is at top center.

Check up the top center mark by making sure that the piston in the cylinder indicated is exactly at top center and that the trammel registers exactly in line.

Now that you are certain of the trammel, move the fly wheel in the direction it should travel(generally counter clock if fly wheel is between you and the cyinders) until the mark I. O. (intake opening) No. 1 and No. 4 registers with the trammel. Leave the fly wheel alone now and turn the cam shaft until the nose of the inlet cam on No. 1 cylinder is down. Adjust the air gap for post card distance Turn the cam shaft in the direction of its travel until the air gap is gone and any further movement would start to lift the valves. Put on the cam shaft gear, being careful to not move either the cam shaft or the crank shaft. Have the gear key in place but don't permanently fasten the gear yet.

Turn the fly wheel in its proper direction and check up the intake closing. If both opening and closing of this valve are right, it means that the cam shaft and air gap are correct and the gear can be permanently fastened.

If the valve opens on time but closes at the wrong time it means that both the cam shaft and air gap are wrong. If the valve closes too soon the air gap is too large and doesn't hold the valve open long enough. If the valve closes late, the air gap is too small and holds the valve open too long. (See page 95.)

Make a mark with a lead pencil or chalk on the fly wheel, midway between the actual closing and the proper closing. Turn the fly wheel to this new mark and adjust the tappet to correspond. The tappet must be just barely in contact with the valve stem. The air gap is now O. K., but the cam shaft is still out of time.

Turn the fly wheel back to the opening mark and remove the gear. Turn the cam shaft until the air gap is gone, replace the gear and check up the closing. The cam shaft and air gap are now correct and the remaining tappets are adjusted after registering each mark with the trammel. Don't use a sheet of paper or post card to measure with. Turn the fly wheel and adjust each tappet by the fly wheel marks.

If the valve opens a certain number of degrees early and closes the same number of degrees late, the cam shaft is right but the air gap is wrong.

If a valve opens a certain number of degrees early and closes the same number of degrees early, the air gap is right but the cam shaft is wrong.

Make a habit of checking up this air gap at least once a month, especially if you have fibre inserts or any other noise silencers. Use the fly wheel marks.

After the valves have been ground or new valves put in—check up. Don't let your engine overheat or lose power through the fault of the air gap.

---

*To assemble timing gears on the Dodge; turn countershaft clockwise until top of No. 4 piston is ⅝" (or 5°) below top of cylinder, on compression stroke. Then rotate cam shaft counter-clockwise until No. 3 exhaust valve is ready to open. The crankshaft and cam shaft gear should then be meshed so that the single punch mark in the latter is between the two on the former.

Where silent chains and sprockets are used instead of gears—the procedure is similar, except the cam shaft revolves in opposite direction.

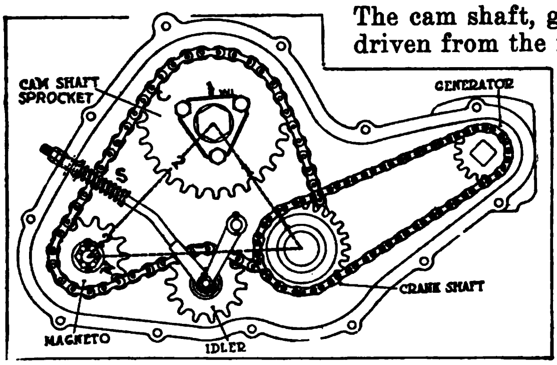


Fig. 2.—Note on the Overland model 75, sprockets and silent chains are used instead of gears.

Note the cam shaft turns the same direction as crank shaft when cam shaft is driven by silent chain.

The cam shaft, generator and magneto shafts are driven from the main shaft by chains at the front of the engine. The timing of these shafts, or the relation of their operation to the crank shaft, determines the time of opening and closing of the valves and the firing of the gas.

Should the chains be removed proceed carefully when reassembling as follows:

Turn the crank shaft until the mark "1-4 UP" on the fly wheel, lines up with the mark on the cross member, and with No. 1 cylinder ready to fire.

Turn the cam shaft until mark 1 on the sprocket is opposite mark 1 on the crank shaft sprocket.

***Now turn the magneto shaft** until the distributor makes contact with No. 1 brush, the lower right-hand one. Mark 2 on the magneto sprocket should now be opposite mark 2 on the cam shaft sprocket.

†**Wrap the chain around the sprockets** and fasten the master link. The parts should now operate in their correct relation. (see also page 648.)

Notes relative to gears: To reach the gears it is usually necessary to remove radiator, then the starting crank stud, then fan, fan pully and gear housing cover. When replacing be sure the gasket of housing is in good condition. The gears are usually keyed and locked in place by a nut on end of shaft. On most gears there are two holes for a "gear puller" (see index), which is used to draw off the gear. **Should it be necessary to remove the cam shaft sprocket from the hub,** see that it is replaced with the tooth marked "O" directly opposite the keyway.

Valve Timing of a 6 Cylinder Engine.

The process is identical with that of a 4 cylinder engine. If all valves are on one side, it is only necessary to time the exhaust valve closing of cylinder No. 1. See page 106 for an example

The timing of a six cylinder engine in *inches instead of degrees is shown below. Also see page 109.

Example of Valve Checking on a 6 Cylinder Engine.

As an additional check, use may be made of the fly wheel markings, as follows:

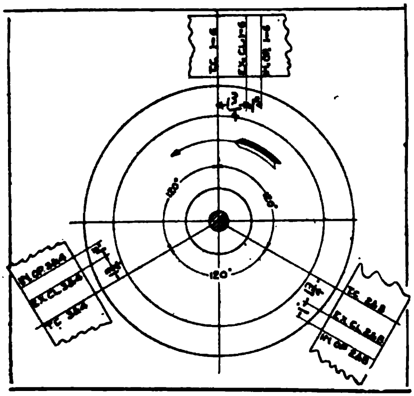


Fig. 3.—Marks on fly wheel of the Marmon 34.

Remove the top cover and twirl between the fingers the long aluminum push rod (for the No. 1 intake valve— the second rod from the front) while someone slowly turns the starting crank. Stop the engine at the exact point when the push rod is no longer free to turn and note the markings on the fly wheel. If the engine is properly timed, the line marked "IN-OP" near "TC 1-|-6" will be directly under the pointer. The exhaust valve is tested in the same way, except that the mark "EX-CL" is used to show the point at which the exhaust valve closes. The point at which the intake closes and that at which the exhaust opens are not shown, as, if the other markings for the same valve are correct, these are sure to be. The marks "TC 1-|-6," "TC 2-|-5" and "TC 3-|-4" designate the top centers of the several cylinders and the timing of each starting from the proper top center is similar to that for No. 1 described above. The marks "IN-OP" and "EX-CL" each refer to the cylinders whose "TC" is nearest. Valve clearance on the Marmon is .003.

---

*See page 115 for conversion of degrees into inches. *See index for valve timing of a 12 cylinder "V" engine. †See index for "repairing silent chains."

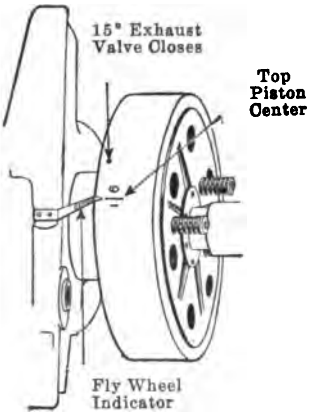


Fig. 4.—Showing the purpose of an "indicator" or "trammel" as applied to a 6 cylinder engine.

Valve Timing "Indicator" or "Trammel."

A trammel or indicator is a stationary starting point to base all work from. It is sometimes attached to the base of a cylinder or other point, instead of a center line on cylinder. It is usually directly over, or in front, of the fly wheel, as per fig. 4 (fly wheel indicator.)

Example of 6 cyl. engine timing: inlet opens and exhaust closing at the same time, or on "**top.**"

When the long mark 1-6 is in line with "**indicator**" on crank case, pistons number one and six are at their highest points or upper dead center. After turning fly wheel to this mark, then turn the fly wheel to the left (when behind it) until the small dot mark is under indicator. This is the point (15°) to set **exhaust** valve just closed. Therefore it is plain to see that setting the exhaust valve just closing on a 6 cylinder engine with valves on the side, is all that is necessary.

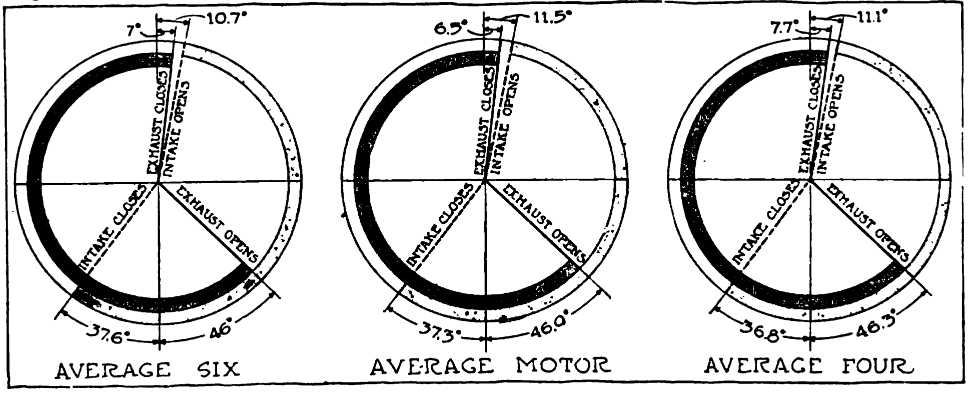


Fig. 3.—Average valve timing diagrams.

Average Valve Timing.

There is very little difference between the average timing of the four and the six cylinder engine. **On the six, the average inlet opening** is 10.7 degrees past top center and closing point 37.6 degrees past bottom center. **On the four the average for inlet opening is** 11.1 after top center and closing point 36.8 degrees after bottom center. The small difference would hardly be noticeable.

The exhaust on the average six opens 46 degrees before bottom center and the four 46.3. The closing point of sixes average 7 degrees after top, and the four 7.7. Therefore, there is very little difference between the four and the six in this respect.

On an average of engines, the intake remains open for a period of 205.8 degrees, and the exhaust remains open for a period of 233.4 degrees. (For an example, see chart 46, page 100, showing how long the valves remain open, or the period of travel.)

To Find Position of Piston.

To find the top or bottom position of piston, see pages 320, 312, for; "Finding Position of Piston."

The best procedure is to calculate the degrees from the center marks on the fly wheel, which are nearly always present either as punch marks, letters, or a simple line filed across the rim. If one person feels the tappet head of the valve which is being checked, while another slowly pulls the fly wheel round in its proper direction of motion, the precise moment at which the valve commences to lift can readily be determined by the binding of the tappet head against the stem of the valve.

Converting inches into degrees:—If the circumference of the fly wheel be then measured in inches by a tape line or its diameter be ascertained and multiplied by three and one-seventh (which amounts to the same thing), the proportion of this measurement to the distance on the rim of the center mark from the perpendicular position will give the degrees of advance or retard.

Suppose for instance, we find that the exhaust valve just closes when the top center mark is 2 inches past the central line in the direction of rotation and that the circumference of the fly wheel is 60 inches. Now there are 360 degrees in a circle, and therefore by the simple process of multiplying this figure by 2 and dividing the result by 60 we get the answer 12 degrees, which is, of course, the number of degrees represented by 2 inches. Also see page 115 for **converting degrees into inches.**

Valve timing on Dodge; first see that valve lifter or tappets are properly adjusted, which is .008 clearance for inlet and .004 for exhaust. Then turn crank shaft clockwise until top of piston No 1 is 1-16 inch **above** top of cylinder on exhaust stroke. Turn cam shaft clockwise until No. 1 exhaust valve is just fully closed. Gears are then meshed.

Diam. Wheel	Circum.	1°	2°	3°	4°	5°	6°	7°	8°	9°	10°	20°	30°	40°	50°
12	37.699	.10	.21	.31	.42	.52	63	73	84	94	1 05	2 09	3 14	4 19	5.24
1/4	38.485	.11	.21	.32	.43	.53	.64	75	86	96	1.07	2 14	3 20	4.27	5.34
1/2	39.270	.11	.22	.33	.44	.55	66	77	87	98	1 09	2.18	3 27	4.36	5 46
3/4	40.055	.11	.22	.33	45	.56	.67	78	89	1.00	1 11	2.22	3 33	4 45	5 56
13	40.841	.11	.23	.34	.45	.57	.68	79	91	1.02	1 13	2.26	3 40	4.54	5 67
1/4	41.626	.12	.23	.35	.46	.58	.69	81	93	1.04	1.16	2.31	3 47	4.63	5.78
1/2	42.412	.12	.24	.35	.47	.59	.71	82	94	1.06	1.18	2.35	3.53	4 71	5 89
3/4	43.197	.12	.24	.36	.48	.60	.72	84	96	1 08	1 20	2 40	3.60	4 80	6.00
14	43.982	.12	.24	.37	.49	.61	73	86	.98	1.10	1.22	2.44	3.66	4.89	6.10
1/4	44.768	12	.25	.37	.50	.62	.75	87	.99	1 12	1.24	2.48	3.73	4.98	6.21
1/2	45.553	.13	.25	.38	.51	.63	.76	89	1.01	1 14	1.27	2.53	3.80	5.07	6.34
3/4	46.338	13	.26	39	.51	.64	.77	90	1 03	1.16	1.29	2.57	3.86	5 15	6.44
15	47.124	.13	.26	.39	.52	.65	79	.92	1.05	1.18	1.31	2 62	3.93	5.25	6.55
1/4	47.909	.13	.27	.40	.53	66	.80	93	1.06	1.20	1.33	2.66	3.99	5 31	6.65
1/2	48.695	.14	.27	.41	.54	.68	.81	95	1.08	1.22	1 35	2.70	4.05	5 40	6.76
3/4	49.480	.14	.27	.41	.55	.69	.82	96	1 10	1.24	1.37	2.75	4.12	5.49	6.87
16	50.265	.14	.28	.42	.56	70	84	98	1 11	1.26	1.40	2.79	4.19	5.59	6 98
1/4	51.051	.14	.28	.43	.57	71	85	99	1.13	1.28	1.42	2.84	4.25	5.68	7.10
1/2	51.836	.14	.29	.43	.58	.72	86	1 01	1.15	1.29	1.44	2.88	4.31	5.76	7.20
3/4	52.622	.15	.29	.44	.59	73	88	1 02	1 17	1.31	1.46	2.92	4.38	5.85	7.30
17	53.407	.15	.30	.44	.59	.74	.89	1.04	1.18	1.33	1.48	2.96	4.44	5.93	7.40
1/4	54.192	.15	.30	.45	.60	.75	.90	1.05	1.20	1.35	1.50	3.00	4.51	6.02	7.53
1/2	54.978	.15	.31	.46	.61	.76	.92	1.07	1.22	1.37	1.53	3.05	4.58	6.11	7.65
3/4	55.763	15	.31	.46	.62	.77	.93	1.08	1.24	1.39	1.55	3.10	4.65	6.20	7.75
18	56.549	.16	.31	.47	.63	.79	94	1.10	1.25	1.41	1.57	3.14	4.71	6.29	7.85
1/4	57.334	.16	.32	.48	.64	.80	.95	1.11	1.27	1.43	1.59	3.18	4.77	6.37	7.95
1/2	58.119	.16	.32	.48	.65	.81	.97	1.13	1.29	1.45	1.61	3.23	4.84	6.45	8.07
3/4	58.905	16	.33	.49	.65	.82	.98	1.14	1.31	1.47	1.63	3 26	4.90	6.54	8.18
19	59.690	.17	.33	.50	.66	.83	.99	1.16	1.32	1.49	1.66	3.32	4.97	6.63	8.30
1/4	60.476	.17	.34	.50	.67	.84	1.01	1.17	1.34	1.51	1.68	3.36	5.04	6.71	8.40
1/2	61.261	.17	.34	.51	.68	.85	1.02	1.19	1.36	1.53	1.70	3.40	5.10	6.80	8.51
3/4	62.046	.17	.34	.52	.69	.86	1.03	1.21	1.38	1.55	1.72	3.45	5 17	6.90	8.62
20	62.832	.17	.35	.52	.70	.88	1.05	1.22	1.39	1.57	1.74	3.48	5.24	6.98	8.73
1/4	63.617	.18	.35	.53	.71	.89	1.06	1.24	1.41	1.59	1.77	3.54	5.31	7.07	8.85
1/2	64.403	.18	.36	.54	.72	.90	1.07	1.25	1.43	1.61	1.79	3.56	5.37	7.15	8.95
3/4	65.188	.18	36	.54	.72	.91	1.09	1.27	1.45	1.63	1.81	3.62	5.44	7.25	9.05
21	65.973	.18	.37	.55	.73	.92	1.10	1.28	1.47	1.65	1.83	3.66	5 50	7.33	9.15
1/4	66.759	.19	.37	.56	.74	.93	1.11	1.30	1.48	1.67	1.85	3.70	5.56	7.41	9.26
1/2	67.544	.19	.38	.56	.75	.94	1.12	1.31	1.50	1.69	1.88	3.75	5.63	7.50	9.38
3/4	68.330	.19	.38	.57	.76	.95	1.14	1.33	1.52	1.71	1.90	3.79	5.69	7.59	9.49
22	69.115	.19	.38	.58	.77	.96	1.15	1.34	1.53	1.73	1.92	3.84	5.75	7.68	9.60
1/4	69.900	.19	.39	.58	.78	.97	1.16	1.36	1.55	1.75	1.94	3.88	5.82	7.76	9.70
1/2	70.686	.20	.39	.59	.79	.98	1.18	1.37	1.57	1.77	1.96	3.93	5.88	7.85	9.82
3/4	71.471	.20	40	.60	.79	.99	1.19	1.39	1.59	1.79	1.98	3.96	5.95	7.94	9.92
23	72.257	.20	.40	.60	.80	1.00	1.20	1.40	1.61	1.81	2.01	4.02	6.02	8.03	10.03
1/4	73.042	.20	.41	.61	.81	1.01	1.22	1.42	1.62	1.82	2.03	4.06	6.09	8.13	10.13
1/2	73.827	.20	.41	.61	.82	1.02	1.23	1.43	1.64	1.84	2.05	4.10	6.15	8.21	10.23
3/4	74.613	.21	.41	.62	.83	1.04	1.24	1.45	1.66	1.86	2.07	4.15	6.22	8.30	10.35
24	75.398	.21	.42	.63	.84	1.05	1.26	1.46	1.67	1.88	2.09	4.19	6.28	8.38	10 45

Conversion Table, Hundredths of an Inch to Sixty-Fourths

01, .02.. 1/64	.14...... 9/64	.26, .27..17/64	.39......25/64	.51, .52..33/64	.64......41/64	.76, .77..49/64	.89......57/64
03...... 1/32	.15, .16.. 5/32	.28...... 9/32	.40, .41..13/32	.53......17/32	.65, .66..21/32	.78......25/32	.90, .91..29/32
04, .05.. 3/64	.17......11/64	.29, .30..19/64	.42......27/64	.54, .55..35/64	.67......43/64	.79, .80..51/64	.92......59/64
.06, .07.. 1/16	.18, .19.. 3/16	.31, .32.. 5/16	.43, .44.. 7/16	.56, .57.. 9/16	.68, .69..11/16	.81, .82..13/16	.93, .94..15/16
.08...... 5/64	.20, .21..13/64	.33......21/64	.45, .46..29/64	.58......37/64	.70, .71..45/64	.83......53/64	.95, .96..61/64
.09, .10.. 3/32	.22...... 7/32	.34, .35..11/32	.47......15/32	.59, .60..19/32	.72......23/32	.84, .85..27/32	.97......31/32
.11...... 7/64	.23, .24..15/64	.36.... .23/64	.48, .49..31/64	.61......39/64	.73, .74..47/64	.86......55/64	.98, .99. 63/64
.12, .13.. 1/8	.25...... 1/4	.37, .38.. 3/8	.50...... 1/2	.62, .63.. 5/8	.75. .... 3/4	.87, .88.. 7/8	1.00...... 1

This table is provided for converting degrees into inches. For instance; if a certain engine is to be timed when inlet opens, say 10° after top of stroke, and there are no marks on fly wheel to indicate this position, by referring to this table the distance in inches to measure on fly wheel from upper dead center mark can be found.

It will be necessary however, to know the diameter of the fly wheel. Suppose fly wheel was 17 inches; refer to first column and find 17, then go out to column under 10° and you have 1.48 (one and forty-eight hundreths of an inch). This would represent the distance to measure for the inlet opening mark on fly wheel.

Forty-eight hundreths (.48) is not so easy to measure on the rule, therefore refer to table below to .48 and note it is equal to 31/64 of an inch. Therefore we would have 1 31/64 of an inch.

Another Example: What would 2½° represent in inches on a 17 inch fly wheel? Procedure: find 17, go out to column under 2° and we find .30. Put this down. Now refer back under column headed 1° and we find .15. One-half of this one degree would be .075 This added to .30 equals .375 Refer to table below and note .375 equals ⅜ of an inch.

CHART NO. 51—Table to Convert Degrees into Inches. Fractions of Hundredths into Sixty-fourths of an inch. (From Horseless Age)

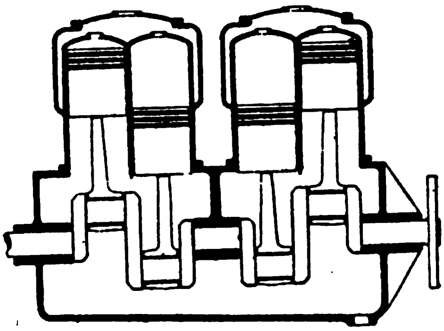


Fig. 1. Four Cylinder Engine: crank shaft set at 180 degrees. Power stroke every half revolution.

Note the shape of crank shaft has an important bearing on the firing order. The actual firing order is governed by the relative position of the cams.

If piston No. 1 is going down say on power, No. 2 must be coming up on either compression or exhaust. If coming up on compression it would fire next. No. 3 would then be coming up on exhaust and No. 4 suction. Therefore the firing order would be 1, 2, 4, 3 (see lower table, bottom of page).

If No. 1 was going down on power and No. 2 coming up on exhaust, then No. 3 would be coming up on compression and would fire next. Therefore the firing order would be, 1, 3, 4, 2.

Remember that the two down strokes are, suction and power. The two up strokes are, compression and exhaust. Each piston must be doing one of the four, during each of the four strokes or two revolutions.

The change of firing is accomplished by the movement of cams on the cam shaft. The cams on cylinder No. 2 and 3 being the only two affected. See below.

If piston No. 1 goes down on power stroke.

Piston No. 2 would be coming up on exhaust stroke if firing order is 1, 3, 4, 2. or Compression stroke if firing order is 1, 2, 4, 3.

Piston No. 3 would be coming up on compression if firing order is 1, 3, 4, 2. or Exhaust if firing order is 1, 2, 4, 3.

Cylinder No. 4 would be going down on suction on either firing order.

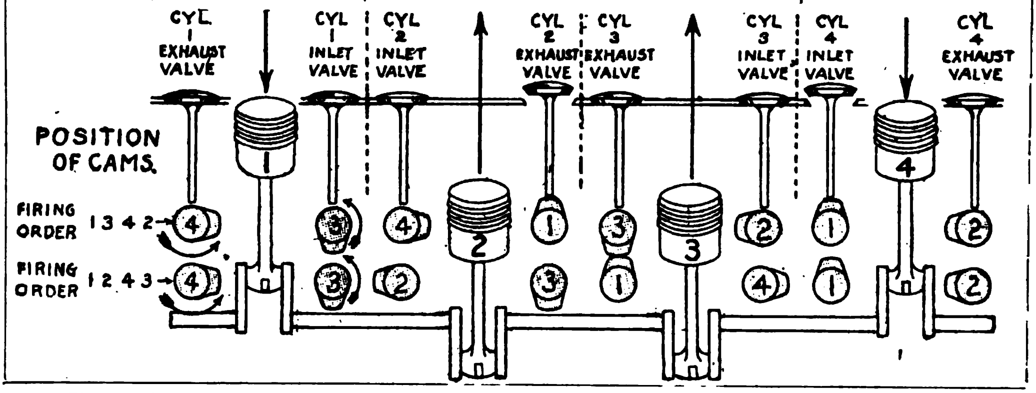


Fig. 2.—Relative position of cams and pistons when No. 1 piston is ready to start down on power stroke. The upper row of cams show position of cams when the firing order is 1, 3, 4, 2.

Note: Cam shaft operated by gears (and not having an idler), turn in opposite direction to crank shaft and just once to the crank shaft twice.

When No. 1 Piston is	No. 2 Piston is	No. 4 Piston is	No. 3 Piston is
STARTING DOWN ON FIRING OR POWER STROKE	Just starting up on COMPRESSION	Just starting down on SUCTION	Just starting up on EXHAUST
Just starting up on EXHAUST	TOP ON FIRING STROKE	Just starting up on COMPRESSION	Just starting down on SUCTION
Just starting down on SUCTION	Just starting up on EXHAUST	TOP ON FIRING STROKE	Just starting up on COMPRESSION
Just starting up on COMPRES-	Just starting down on SUCTION	Just starting up on EXHAUST	TOP ON FIRING STROKE

The lower row of cams show position when the firing order is 1, 2, 4, 3.

Referring to fig. 5, page 58, note numbers on cam denote position. Each stroke of the piston, or half revolution of crank, the cams travel 90 degrees or ¼ of a revolution.

HOW THIS FOUR CYLINDER ENGINE FIRES 4 times during two revolutions of the crank shaft or four strokes of the piston. Fires 1, 2, 4, 3; diagram to the left, and 1, 3, 4, 2; diagram to the right.

It will be noticed that to change from one firing order to another, merely the cams on valves of cylinders 2 and 3 are changed. (Also the ignition wires.)

When No. 1 Piston is	No. 3 Piston is	No. 4 Piston is	No. 2 Piston is
STARTING DOWN ON FIRING OR POWER STROKE	Just starting up on COMPRESSION	Just starting down on SUCTION	Just starting up on EXHAUST
Just starting up on EXHAUST	TOP ON FIRING STROKE	Just starting up on COMPRESSION	Just starting down on SUCTION
Just starting down on SUCTION	Just starting up on EXHAUST	TOP ON FIRING STROKE	Just starting up on COMPRESSION
Just starting up on COMPRES-	Just starting down on SUCTION	Just starting up on EXHAUST	TOP ON FIRING STROKE

CHART NO. 53—Firing Order of a Four Cylinder Four Cycle Engine. Relative Cam Movement to Crank Movement. (See charts 55, 62 and 65, for explanation of firing order of a Six, Eight and Twelve (twin six) cylinder engine.)

How to tell firing order of engine by position of cams; see page 120.

Chart 52 on page 118.

INSTRUCTION No. 10.

FIRING ORDER: One, Two, Three and Four Cylinder Engines.

†Firing Order of One and Two Cylinder Engines.

There are four strokes to two revolutions of the crank to complete a cycle operation, as explained in chart 29.

A stroke of the piston means a travel from top to bottom or bottom to top, or 180 degrees movement, or one-half of a revolution of the crank shaft.

There is but **one power stroke during the four strokes**, or two revolutions of the crank shaft. Also note that the power stroke is a very short one; owing to the fact that the exhaust valve starts to open considerably before piston reaches bottom of its stroke. If the exhaust valve should open 46 degrees before bottom, then the travel on power stroke would be but 134 degrees instead of 180 degrees.

Therefore, if there is but one power stroke to two revolutions of the crank shaft, we would have only 134 degrees out of the two revolutions, (or 720 degrees travel of crank) on which there is power. (See chart 46.)

In an engine with one cylinder (fig. 1, chart 52), there is an **explosion once during** every two revolutions of the crank shaft, or in other words, there is one stroke of the piston when power is being developed, and three when there is no power, the piston then being moved by the momentum of the fly wheel.

As the piston must be carried through the three dead strokes, it is necessary to use a heavy fly wheel, so that when it is started it will continue to revolve for a sufficient time to move the piston until the next power stroke.

There is vibration from a one cylinder engine on this account for the weight of the piston sliding first one way and then the other has nothing to balance it.

It can be balanced to some extent by attaching a weight called a "counter balance," (fig. 12, chart 36), to the crank shaft opposite to the crank pin, in the same manner that the wheels of a locomotive are balanced, but even so there is vibration owing to power stroke at intervals.

An engine with two cylinders: one piston can be arranged to slide inward as the other slides outward, so that one balances the other, as in fig. 4, page 118. This type of engine is called an **opposed** type of engine. Cylinders are set 180 degrees apart, also crank shaft. When one piston starts down on power stroke, the other would start down on suction, therefore referring to the scale under fig. 4, note there would be a firing impluse at each revolution of the crank shaft or every 360°. There is still vibration, however, as the power stroke is not continuous.

The two types of **twin vertical** cylinder engines, figs. 2 and 3, page 118, are explained in text matter in the chart. Fig. 2 would cause considerable vibration, as would also fig. 3.

The fly wheel of a two cylinder engine need not be as heavy as that of an engine with one cylinder, because it is required to carry the piston through only one dead stroke before another power stroke occurs. On 6, 8 and 12 cylinder engines, the fly wheel is very small in diameter.

The more cylinders an engine has, the more steadily it may run, for the explosions may be arranged to follow one another so closely that there is no moment when one of the pistons is not on the power stroke.

**Firing Order of a Three Cylinder Engine.

Three cylinder engine fires 1, 3, 2 from front of engine or 1, 2, 3 if from rear.

The action of the firing of a three cylinder engine is this: Taking three points of the circle (see page 119.) A at the top, B and C on each side below, the piston of No. 1 cylinder is connected with a crank at A, to No. 2 cylinder at B and to No. 3 cylinder at C.

---

†See pages 122, 131, 135, for firing order of 6, 8 and 12 cylinder engines.

*See "standard adjustment of leading cars" for firing order of different automobile engines; also see Dyke's working model of the 4 and 6 cylinder engine.

**Based on exhaust interval being equal to 180 degrees travel. In actual practice it is more—See page 100.

Firing Order of One, Two and Three Cylinder Engines.

Fig. 1—Single cylinder engine, with crankshaft set at 360°: There are four strokes of 180° on all four cycle engines, therefore, there would be two revolutions of 360° each, or 720° travel of crank.

If the firing stroke started on top and traveled to within 46° of bottom when exhaust opened, there would be but 134° of the 720° on which the piston traveled on power.

There is **one power stroke (firing impulse), every two revolutions** of the crankshaft on one cylinder, four cycle engines—see diagram fig. 1, below.

Single cylinder engines usually have counter-weights on the crank arms or fly wheel to counter-balance same.

Fig. 2—Two cylinder vertical engine with a 360° crankshaft: If piston of No. 1 cylinder is on power (P), No. 2 would be on suction (S)—see diagram below—therefore we would get an even firing impulse, or **one during each revolution.** But as both pistons are moving together, there would be considerable vibration, as both are on top or bottom at the same time. Counter weights are also used on the crankshaft of this type of engine in order to counter-balance.

Fig. 3—Two cylinder vertical engine with a 180° crankshaft: There are two firing orders of this engine, both of which would cause vibration. Refer to diagram and note first one. If No. 1 is on power (P), No. 2, would be coming up on compression (C), and would fire next. Therefore, there would be **two firing or power impulses during one revolution,** and on the second revolution there would be no firing impulse at all.

With the other order of firing; if No. 1 was on power (P), No. 2 would be coming up on exhaust (E), **the crank would therefore travel 540°, or 1½ revolutions with but one firing impulse.**

Fig. 4—Two cylinder engine with cylinders opposite and crankshaft set 180°: This type of engine **gives a firing impulse every revolution**—see diagram below—it is mechanically balanced.

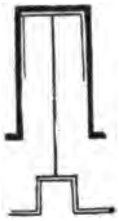


Fig. 1—One cylinder engine with a 360° crankshaft.

Firing impulse every two revolutions — see diagram below.

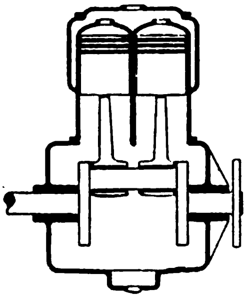


Fig. 2—Two cylinder vertical engine with a 360° crankshaft.

Firing impulse every revolution.

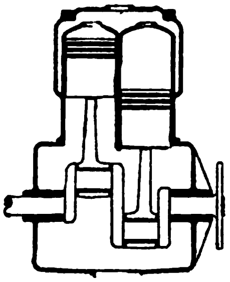


Fig. 3—Two cylinder vertical engine with a 180° crankshaft.

Two different firing orders —see diagram below.

CYLINDER NO.	1
1ST REVOLUTION	S C
2ND REVOLUTION	P E

1	2	CYLINDER NO
P E	S C	1ST REVOLUTION
S C	P E	2ND REVOLUTION

CYLINDER NO	1	2
1ST REVOLUTION	P E	C P
2ND REVOLUTION	S C	E S

OR

CYLINDER NO.	1	2
1ST REVOLUTION	P E	E S
2ND REVOLUTION	S C	C P

P—means power stroke. S—suction. C—compression. E—exhaust. The "power stroke" is also termed the "firing impulse."

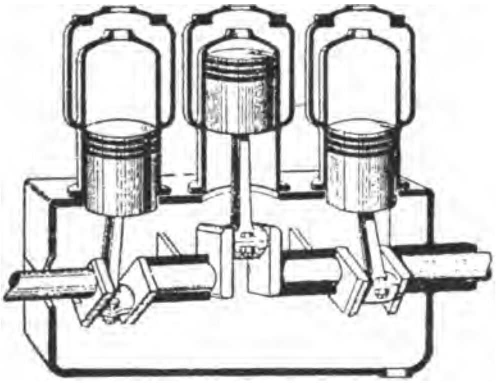


Fig. 5—A three-cylinder engine crank, set in three positions or third of a revolution, or 120 **degrees apart.** (See text for explanation, page 117.)

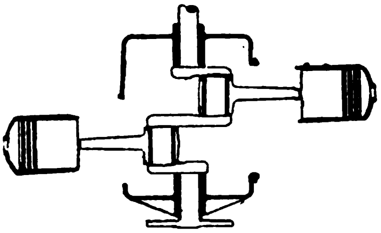


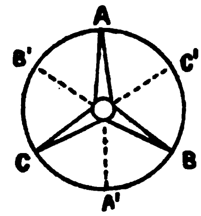
Fig. 4—Two cylinder, opposed type engine with 180° crankshaft.

CYLINDER NO.	1	2
1ST REVOLUTION	P E	S C
2ND REVOLUTION	S C	P E

Firing impulse every revolution. Mechanically balanced.

CHART NO. 52—Firing Order of One, Two and Three Cylinder Engines.

Chart 54 on page 121.



No. 1 cylinder will be at full compression, No. 2 cylinder at two-thirds inspiration, and No. 3 cylinder one-third, exhaust 240°.

No. 1 cylinder: The crank of this performs its half revolution, bringing it to position A', midway between points B and C.

Whilst it is doing this, No. 2 cylinder is completing its inspiration stroke, and two-thirds of its compression stroke, and the crank is passed on to position B', leaving only one-third of a stroke to complete compression, and bring the crank to A, when the firing of B commences.

Meanwhile C is completing its exhaust and inspiration strokes, and has passed through two-thirds of its compression stroke, so that when No. 2 cylinder has completed its impulse, No. 3 has but to be carried over the small gap by the fly wheel, which gap represents the minus lap.

Each of the three cylinders fire once every 720° (two revolutions), or 240° apart.

No. 1 (A) fires and moves 240 degrees, which brings No. 2 (B) in firing position. No. 2 (B) fires and moves 240 degrees, which brings No. 3 (C) in firing position. No. 3 (C) fires and moves 240 degrees, which again brings No. 1 (A) in firing position.

No. 1 (A) has now made two revolutions or 720 degrees, which completes the four cycle evolution.

The working stroke is 134 degrees, therefore 240 degrees less 134 degrees equals 106 degrees, during which time no work is being done (—106° lap), that is, the fly wheel carries the crank 106°.

Firing Order of a Four Cylinder Engine.

Four cylinder engines are so arranged there is a **power or firing impulse every stroke**, or two firing impulses every revolution, one beginning as the previous one ends.

In order to complete the four cycle evolutions of suction, compression, explosion and exhaust for each piston, it is necessary that each piston have four strokes. As 1 and 4 work together and 2 and 3 work together, then four strokes; two up and two down, or two revolutions of the crank shaft will give the complete cycle evolution for each piston, with a firing order of either 1, 2, 4, 3, or 1, 3, 4, 2. (See diagrams bottom of page 116.)

The crank shaft of a four cylinder four cycle engine is always set at 180 degrees. (See pages 78 and 116.)

Note the "throws" of a four cylinder crank shaft (see fig. 1, page 116); 1 and 4 (end cranks) are in line, and 2 and 3 (inside "throws" or cranks), are in line—therefore 2 and 3 are one-half revolution, or 180° from 1 and 4.

The construction of the crank shaft would not permit the firing to be 1, 2, 3, 4, because, when 2 was ready to go down on power stroke, 3 would have to be coming up on compression, but as 3 is always the same position as 2, then it could not be coming up, as it would already be up with 2. (See fig. 1, page 116.)

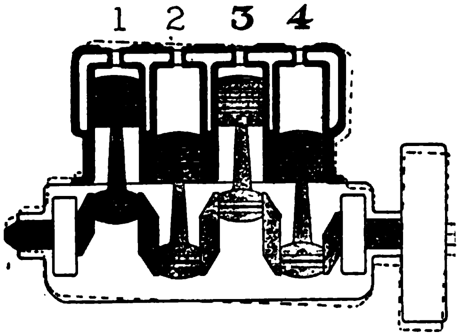


Fig. 2.—Type of crank shaft which would permit a four cylinder engine to fire 1, 2, 3, 4, but is never used.

Type in general use, see fig. 1, page 116.

For the reason that 1 and 4 are together (up or down), and 2 and 3 are together (up or down), the firing order must be 1, 2, 4, 3, or 1, 3, 4, 2. (See page 116.)

A four cylinder engine could be made to fire 1, 2, 3, 4, by having crank shaft made as per fig. 2, but it would vibrate excessively on account of the rocking motion of firing from one end to the other. Therefore the firing order on all engines is arranged to **decrease vibration** as much as possible. The alternate distribution of impulse (firing) tends to steady the engine, as 1, 2, 4, 3, or 1, 3, 4, 2.

Cylinders are originally made to fire in proper order by the manufacturer, by setting the cams on the cam shaft (see fig. 2, page 116), and commutator or distributor wired to connect with the proper spark plugs (see charts 144 and 145).

The order of firing depends on the ideas of the maker, and may be either, 1, 2, 4, 3, or 1, 3, 4, 2, on a four cylinder engine.

The eight "V" type of cylinder engine, uses a four cylinder 180 degree crank shaft with two connecting rods to one crank pin. See chart 36, page 78.

The twin six or twelve "V" type engine uses a regular six cylinder crank shaft. This will be treated farther on, together with firing order. Also see charts 62 to 65.

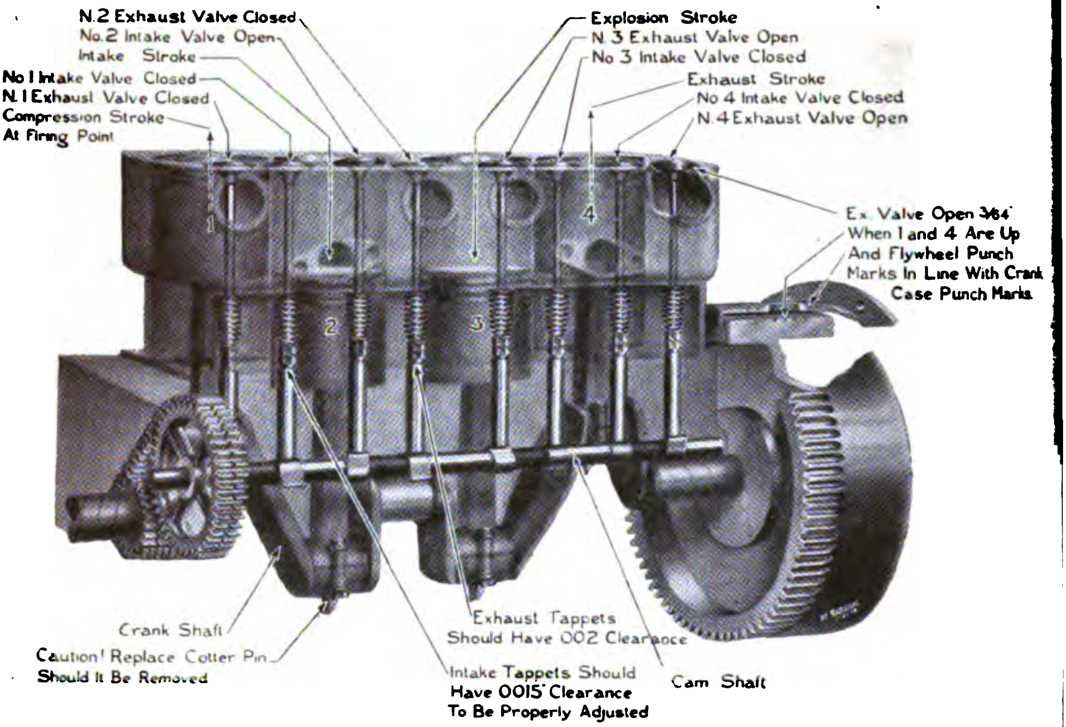


Fig. 3: Illustration showing how the cam shaft with its cams are driven by a silent chain sprocket. Also note the **mark on fly wheel** in line with punch mark on **crank case** when pistons 1 and 4 are on upper dead center which they are now, pistons 2 and 3 are on **lower** dead center. (No. 1 is next to timing gears) at this point, the setting of valves and gears are determined.

For instance, if the exhaust must close say at 10° past upper dead center, then the fly wheel is revolved in the direction of rotation 10° from upper dead center. Then **at this point** the exhaust valve of No. 1 cylinder should just close. **This is sufficient** as **all other** valves will be timed to open and close at the correct time.

If the exhaust did not close at 10° past dead center, then it is either because **the clearance** of the **exhaust valve tappet** is set too close and holds the valve open too **long,** or the **cam shaft gear is not meshed** properly. (See pages 102 and 112.)

The firing order of above engine can be determined by observing the position of the pistons and valves: Exhaust and inlet of No. 1 are closed; piston of No. 1 cylinder **is** at top of compression and will go down on **power** stroke. Piston of No. 2 cylinder **is at** bottom of its intake stroke and will come up on compression; inlet valve still open **and** exhaust closed. Piston of No. 3 cylinder is at bottom of its stroke and will come up **on** exhaust stroke; exhaust valve is open and intake valve is closed. Piston of No. 4 cylinder is at top of its stroke and will go down on suction; exhaust valve will close **within** a 10° movement of crank shaft (note exhaust cam just leaving the No. 4 exhaust **valve tappet**), and the inlet will open immediately as piston starts down.

Now to determine the firing order: If No. 2 will come up on compression as No. 1 piston goes down, and if the power stroke follows immediately after the **compression** stroke, then No. 2 will fire next. Therefore firing order must be 1, 2, 4, 3. The **only** other firing order it could possibly have, would be 1, 3, 4, 2—but this is impossible **because** No. 3's exhaust valve is open and it will come up on exhaust, then after exhaust **comes** suction. No. 3 has just fired, therefore No. 1 will fire next.

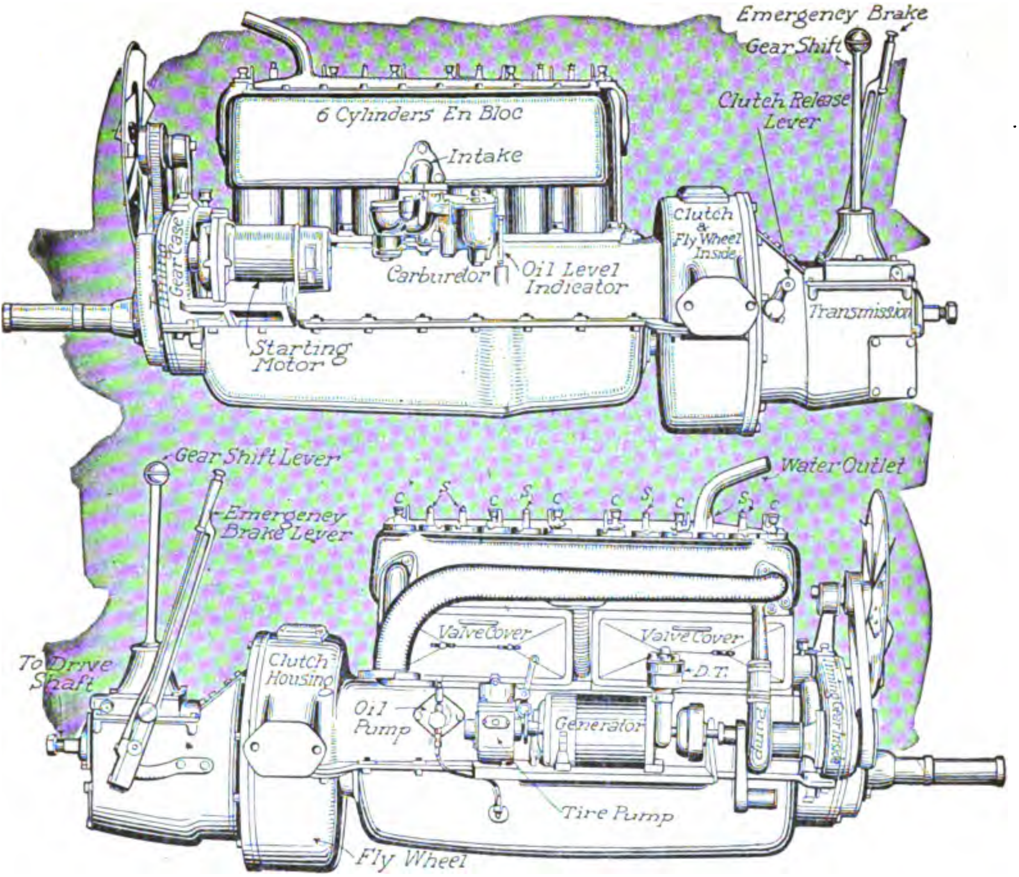
A quick way to determine firing order of a four cylinder engine: when nose **of first** and **third** cam (inlet or exhaust) are on opposite sides of a shaft; engine fires 1, 2, 4, 3. When first and third cams are on the same side of shaft; firing order is 1, 3, 4, 2.

Note—Cam shafts operated by silent chains and sprockets turn in the **same** direction as **the** crank shaft and just once to the crank **twice.**

Cams in fig. 2, page 116 are made to open and close exactly on a stroke of the piston or 180° movement of crank, which is unusual in actual practice.

On above engine, fig. 3, the cams are set as in actual practice, for instance, the above valves open and close as follows: **Exhaust** closes 10 degrees after top. **Inlet** opens 6 degrees **after top. Exhaust** opens 50 degrees before piston is at bottom dead center. **Inlet** closes 40 degrees **after** bottom dead center. The **bore** of cylinders is 3¾ inches diameter and the **stroke** of piston is 4¼ **inches.**

The make of above engine is the Golden Belknap and Swartz Co.'s. model E-M 31, four cylinder side valve detachable head engine. Horse power is 22½ at 935 feet of piston speed per **minute.** Produces 36.9 h. p. at 2,800 r. p. m. on actual brake test and 31.9 h. p. at 2,000 r. p. m.



Left and right hand view of a modern type of six cylinder engine power plant.

"Unit Power Plant," meaning engine, clutch, and transmission are all in one unit.

Cylinders are cast "in block." Clutch encased with fly wheel and disc type. **Valves** "L" type enclosed. Gear control by "ball and socket" type of gear shift lever. **Generator** driven from pump shaft. **Starting motor drives** crank shaft. Note the **spark plugs** (S) are usually over the **inlet valves.**

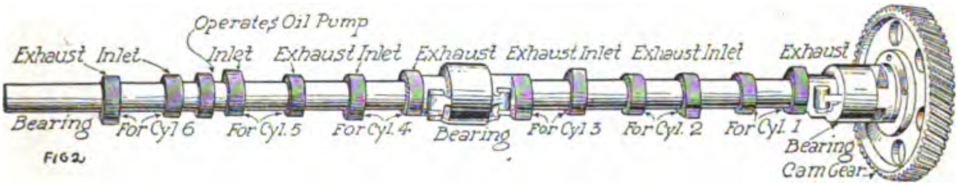


FIG 2

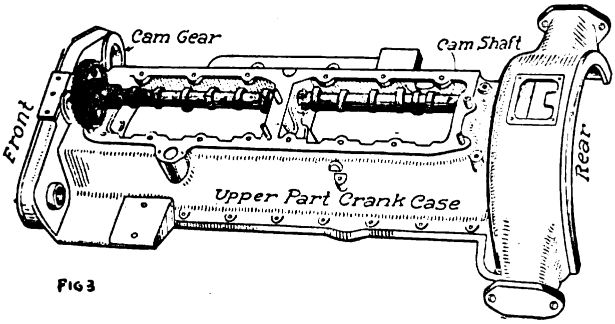


FIG 3

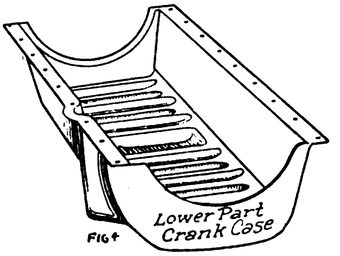


FIG 4

Note the cams on this the "L" type engine are all on one cam shaft. Cam gear meshes with a gear on crank shaft. Note: "upper part crank case," now known as "crank case." "Lower part crank case," now known as "oil pan.",

CHART NO. 54—Right and Left Side View of a Modern Six Cylinder Automobile Engine. (Th Haynes).

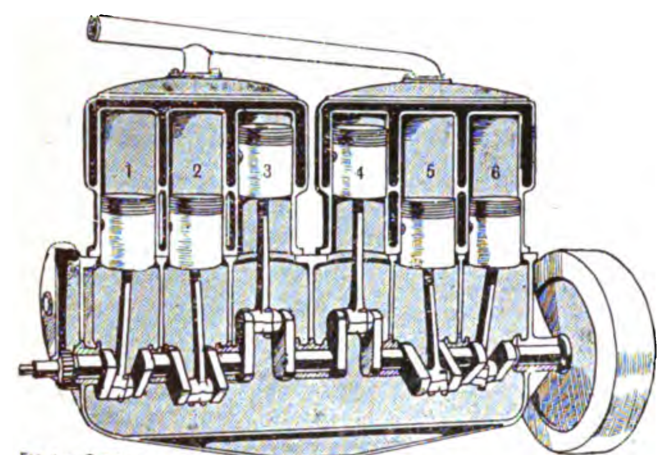


FIG. 1.—SIX-CYLINDER ENGINE WITH SEVEN BEARINGS TO THE CRANKSHAFT AND CYLINDERS CAST IN TWO BLOCKS OF THREE.

Fig. 1. Note piston and crank 1 and 6 are in line with each other. Also 3 and 4 and 2 and 5. An end view is shown in fig. 2. Firing order of above is 1. 5, 3, 6. 2, 4. No. 5 has just fired. No. 3 will fire next, then 6, 2, 4—see illustration, fig. 2, for explanation.

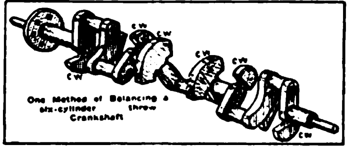


Fig. 3. Counter balance weights applied to a six cylinder crank shaft with the result that the engine attains a speed of 2,500 revolutions per minute without detrimental vibration.

Bearings on the six cylinder crank shaft are usually three, as per fig. 5, below.

Sometimes seven bearings are used as illustrated in figs. 1 and 4.

The right and left hand crank shaft, referred to on page 123 are illustrated below.

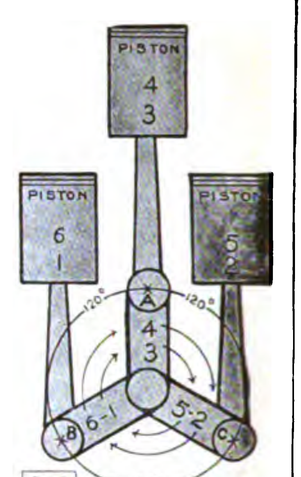


FIG 2.

Fig. 2. This is an end view of crank shaft in fig. 1 illustration. Cylinders are in line with each other, when in cylinders. In this illustration they are supposed to be out of cylinders, hence not in line.

The throws of a 6 cylinder crank are divided into three parts, or 120° apart.

1 and 6 are always in line
3 and 4 are always in line
2 and 5 are always in line

but they may be placed to the left or to the right as shown in figs. 4 and 5.

On the above; firing order could be 1, 5, 3, 6, 2, 4 or 1, 2, 4, 6, 5, 3. Assume that we are standing in front of engine; No. 5 has just fired, No. 3 will fire next, then 6, 2, 4.

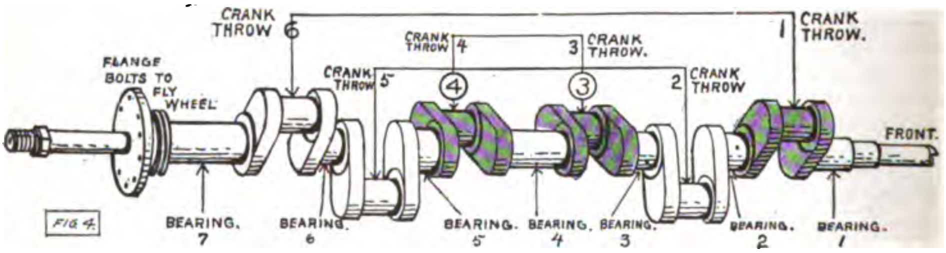


FIG 4.

Fig. 4. A right hand 6 cylinder crank shaft, is determined by noting position the center throws, 3 and 4 are to 1 and 6. If they are to the right of 1 and 6, as shown above and as illustrated in fig. 1, page 124, then it would be a right hand crank (view from front).

A right hand crank will fire 1, 5, 3, 6, 2, 4 or 1, 2, 4, 6, 5, 3.

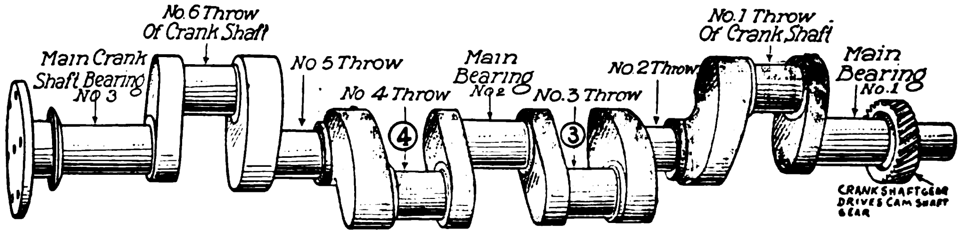

No. 6 Throw Of Crank Shaft
Main Crank Shaft Bearing No 3
No 5 Throw
No 4 Throw
Main Bearing No 2
No. 3 Throw
No. 2 Throw
No. 1 Throw Of Crank Shaft
Main Bearing No. 1
4
3
CRANK SHAFT GEAR DRIVES CAM SHAFT GEAR

Fig. 5. A left hand 6 cylinder crank shaft; note 3 and 4 throws are to the left of 1 and 6 as illustrated, also in fig. 2, page 124.

Therefore it would fire, 1, 4, 2, 6, 3, 5 or 1, 3, 5, 6, 4, 2.

CHART NO. 55—Crank Shafts of a Six Cylinder Engine.

INSTRUCTION No 11.

SIX, EIGHT and TWELVE "V" TYPE CYLINDER ENGINES. Rotary Valve and Rotary Cylinder Engines. Sleeve Valve Engine. Overhead Cam Shaft Engine.

The Six Cylinder Engine.

The variance in construction is principally in the addition of more cylinders and the shape of the crank shaft.

The cylinders may be in "pairs" or in "triplets" or "in block." The usual order is in two blocks, of three to a block. Cylinders on a six cylinder engine are usually "L" type.

The six cylinder engine operates on the four cycle principle, the same as the four cylinder; in fact the general principle is used; the **crank shaft** must turn two revolutions during the cycle or four strokes. The **cam shaft** turns one revolution. The shape of the crank shaft of a six makes it possible for each piston to complete the four strokes—see figs. 1 and 2, chart 55; note the crank shaft is divided into three pairs of "throws." Pistons 1 and 6 are in line; 3 and 4 are in line and 2 and 5 are in line. A "throw" on a crank shaft is the part to which the big end of connecting rod connects and is really the "crank pin." Each pair of these crank shaft "throws" (1 & 6 & 3 & 4 & 2 & 5) are placed 120 degrees or 1/3 the distance of a circle apart.

There are six power impulses or explosions during two revolutions of the crank shaft, therefore the magneto armature* turns 1½ revolutions to one of the crank shaft. When piston, say No. 1 goes down on firing stroke, it must make a full stroke or 180 degrees or ½ of a revolution of the circle, it could not stop at 120—see chart 57 for explanation, also fig. 2, page 122.

A degree is 1/360th part of a circle. There are 360 degrees to a circle. This mark, ° which is nothing more than a small "0" to the side of a figure, represents degrees. For the crank shaft to make one revolution, it must make a complete circle or 360 degrees. Although each pair of "throws" of the crank shafts are placed 120 degrees apart, this would place one pair, say pistons 4 and 3 at A, another pair pistons say 5 and 2 at B, 6 and 1 at C. Each pair would be 1/3 the circle apart.

There are two kinds of six cylinder crank shafts; left hand and right hand—see figs. 4 and 5, page 122. The cylinders usually fire on a right hand crank 1, 5, 3, 6, 2, 4, while on a left hand the order is usually 1, 4, 2, 6, 3, 5—see pages 124 and 122.

The number of bearings for the six crank shaft may be 3, or 7. Three bearings is the usual number. **The carburetion.** A six cylinder engine usually requires special intake pipes and double or multiple jet type of carburetor to meet the demand of the multiple of cylinders and distance the carburetted gas must travel. **The timing** of six cylinder valves is identical with that of the four. The process is gone through with just in the same manner. It is only necessary to time with the **exhaust valve closing** on the first cylinder and the "L" type, and on "T" head type, with exhaust valve closing on exhaust side and inlet opening on inlet side.

If the reader will turn to charts 55, 56 and 57 the explanation of the six cylinder engine will be made more clear.

---

†See Dyke's working model of the six cylinder engine. *If a timer and distributor, they turn one revolution to the cranks two, or same as the cam shaft. See index "ignition timing." ‡See foot note bottom of page 79.

*See "Specifications of Leading Cars," page 543, for cars using 6 cylinder engines.

Firing Order of a 6-Cylinder "Right Hand" Crank.

Fig. 1.

Firing order 1, 5, 3, 6, 2, 4, (could also fire 1, 2, 4, 6, 5, 3.)

Illustration shows pistons 1 and 6 up. If No. 1 starts down on "firing," No. 5 would be coming up on compression, as it would fire next. No. 3 would be 120° behind No. 5 and would fire next. No. 6 being 120° behind No. 3, it would fire next, then No. 2, then No. 4.

To get the second firing order (1, 2, 4, 6, 5, 3.) start with No. 1, then 2, 4, 6, 5 and 3. Note. View from front of engine. Although pistons are shown out of line, this is necessary in order for the reader to understand the relative positions, one to the other. When in cylinders they are all in line and the connecting rods are out of line.

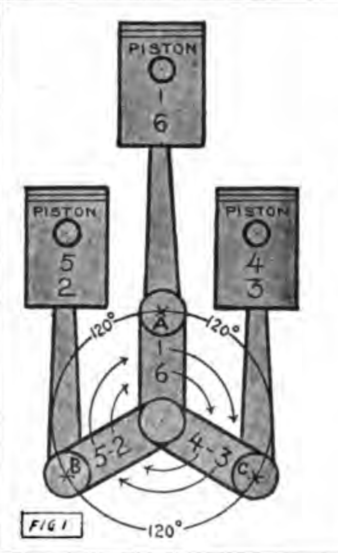


FIG 1

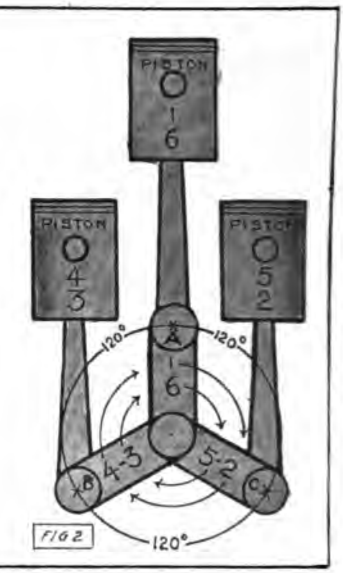


FIG 2

Firing Order of a 6-Cylinder "Left" Hand Crank.

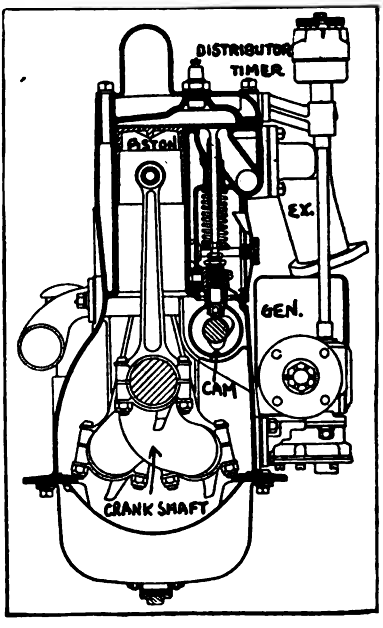
Fig. 2.

Firing order, 1, 4, 2, 6, 3, 5, (could fire 1, 3, 5, 6, 4, 2). If No. 1 starts down on firing, No. 4 would fire next, then No. 2, then 6, 3 and 5 in their respective order.

To get second firing order (1, 3, 5, 6, 4, 2,) start with No. 1, then No. 3, 5, 6, 4 and 2. Note view is supposed to be from the front of engine.

HOW THE SIX CYLINDER ENGINE FIRES
6 Times During Two Revolutions of the Crank Shaft, or Four Strokes of the Piston.

FIRING ORDER (See Fig. 2.)	When No. 1 Piston is	No. 4 Piston is	No. 2 Piston is	No. 6 Piston is	No. 3 Piston is	No. 5 Piston is
FIRING ORDER (See Fig. 1.)	When No. 1 Piston is	No. 5 Piston is	No. 3 Piston is	No. 6 Piston is	No. 2 Piston is	No. 4 Piston is
	TOP ON FIRING	1/3 of revolution from top of up compression stroke	1/3 of a revolution from top on down intake stroke	Top on Exhaust	1-3 of a revolution from top on up exhaust stroke	1-3 of a revolution from top on down firing stroke
	1/3 of a revolution from top on down firing stroke	TOP ON FIRING	1/3 of a revolution from top on up compression stroke	1/3 of a revolution from top on down intake stroke	Top on Exhaust	1-3 of a revolution from top on up exhaust
	1/3 of a revolution from top on up exhaust stroke	1/3 of a revolution from top on down firing stroke	TOP FIRING	1/3 of a revolution from top on up compression stroke	1-3 of a revolution from top on down intake stroke	Top on Exhaust
	Top on Exhaust	1/3 of a revolution from top on up exhaust stroke	1/3 of a revolution from top on down firing stroke	TOP FIRING	1-3 of a revolution from top on up compression stroke	1-3 of a revolution from top on down intake stroke
	1/3 of a revolution from top on down intake stroke	Top on Exhaust	1/3 of a revolution from top on up exhaust stroke	1/3 of a revolution from top on down firing stroke	TOP FIRING	1-3 of a revolution from top on up compression stroke
	1/3 of a revolution from top on up Compression stroke	1/3 of a revolution from top on down intake stroke	Top on Exhaust	1/3 of a revolution from top on up exhaust stroke	1-3 of a revolut on from top on down firing stroke	TOP FIRING



An end view of the Chalmers six cylinder engine ("6-30") is shown to the right. The firing order of this engine is 1, 4, 2, 6, 3, 5—see the top row in table to the left.

This illustration is shown, in order that the reader may see just how the pistons are all in line when in the cylinders, instead of being out of line as shown in the exaggerated drawings, figs. 1 and 2.

Timing Chalmers valves: Turn the fly wheel, bringing the mark "Ex. Cl." (exhaust closes) on the fly wheel, exactly in line with the centered reference mark pointer on the rear of the crank case. With the fly wheel mark in this position, the exhaust valve on the No. 1 cylinder should just close. If not, adjust the exhaust cam so it is at the closing point.

It is essential that these adjustments shall always be made with the "back lash" or lost motion in the driving gear entirely taken up in the same direction, that is, in the direction of the rotation of the engine when running.

CHART NO. 56—Two Firing Orders of a Six Cylinder Engine Explained.

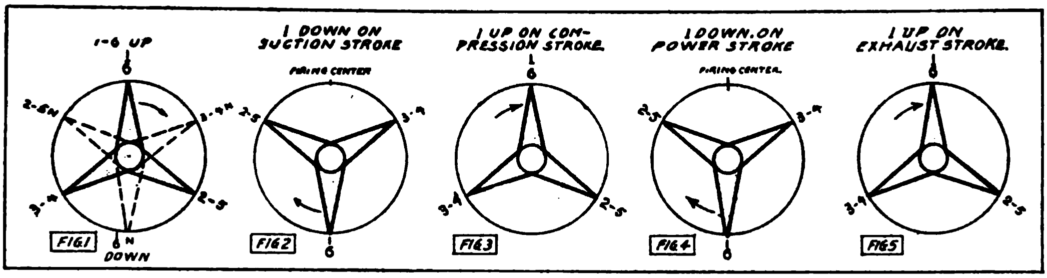


Fig. 1.—Relative position of Pistons on a Six Cylinder Engine. View of illustrations are in front of engine—hence cranks are rotating to the right.

Note pistons must make a full stroke, up or down and crank throws must travel 180° at each stroke, or ½ revolution just the same as a four cylinder.

In order however, to show how and when the cylinders can fire 6 times during two revolutions of the crank shaft—the above illustration and the firing table in Chart 56 is provided.

The pistons must go from the extreme top to the bottom at each explosion or stroke.

***Fig. 1—If 1 and 6 pistons go down** on say, firing stroke, then they would go to bottom "1-6 N down," which is a half revolution of the crank or one stroke or 180°.

Then pistons 2 and 5 would be at dotted line position "2-5 N;" 3 and 4 pistons would be at dotted line position "3 and 4 N."

Therefore we have an "over lapping" of strokes—see Chart 58.

Only two of the six cranks are on dead center at the same time. The firing point is at top.

Fig. 2.—Note position of 2-5 and 3-4 after 1 and 6 have just made a half revolution or suction stroke down. They have both moved 180°. Also note that as 3 and 4 passed the top, or firing center, either 3 or 4 must have fired.

Fig. 3.—1 and 6 have now made another stroke up, on compression, (stroke No. 2), or 180° more or 360° in all, or a revolution. Note 2 and 5 passed the firing point during this stroke; therefore either 2 or 5 must have fired.

Fig. 4.—1 and 6 have now made another stroke down on power and fired, (stroke No. 3) or 180° or 1½ revolutions in all. During this stroke, 3 and 4 passed the firing point again and one or the other must have fired.

Fig. 5.—1 and 6 have now made its fourth stroke, up on exhaust, or another 180° or 2 revolutions in all. During this stroke 2 and 5 passed the top center firing point again, and either 2 or 5 fired.

Note we have followed out the four strokes, during two revolutions, and during the four strokes, there were 6 explosions, or power impulses, as the pistons passed the top.

A six differs from a four cylinder engine, only in the shape of crank shaft, which is divided into thirds instead of halves.

---

*Note when 1 and 6, or either pair go down or up; only one of the pair is on firing or compression. Both could not be on firing at the same time. (See Chart 56). However, in order to explain how the cranks travel in pairs we will not state which one of the pair is on the above mentioned stroke.

CHART NO. 57—How the Six Cylinder Engine makes Six Impulses during Two Revolutions of the Crank Shaft.

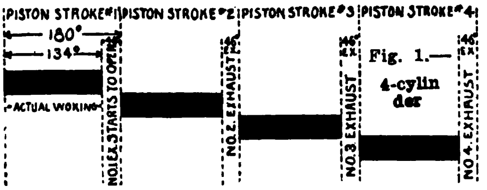
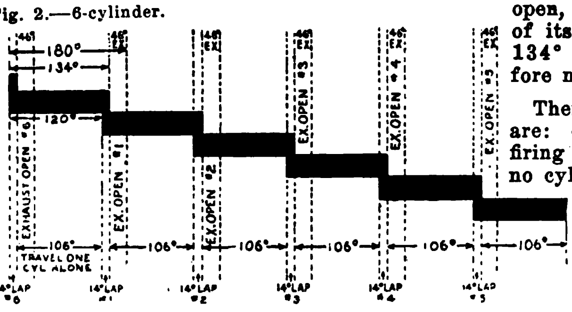


Fig. 1.—4-cylinder

Fig. 2.—6-cylinder.



4 Cylinder Lap.

On a 4 cylinder engine there are four periods of 46° travel or 184° in all, during the four strokes that there is no power.

Referring to illustration, fig. 1, note, if piston No. 1 is firing, it does not travel its full stroke with a crank movement of 180° on power, because the exhaust valve starts to open, say 46° before it reaches the bottom of its stroke, therefore it really travels but 134° on its power stroke. Consequently, before next piston fires there is a gap of 46°.

Therefore, in a four cylinder engine there are: 4 periods of 134° when 1 cylinder is firing or working and 4 periods of 46° when no cylinder is firing or working.

The fly wheel must take the pistons over center during the "no" working strokes.

6 Cylinder Lap.

On the six cylinder engine; each piston is working on all of its stroke of 180° except 46°, leaving 134° actually working.

The second cylinder to fire, starts to work 120° after the first starts to work, and works 14° before the exhaust opens or the impulse ends on the first cylinder. Consequently there is no idle space between the firing of cylinders, but quite the reverse, for there is a lapping of power strokes.

There are 6 periods of 106° travel when one cylinder is working alone and 6 periods of 14° travel when two cylinders are working together.

Therefore 7-60ths of the time 2 cylinders are working together and 53-60ths of the time 1 cylinder is working alone.

FIG. 3-8 CYLINDER "V" TYPE

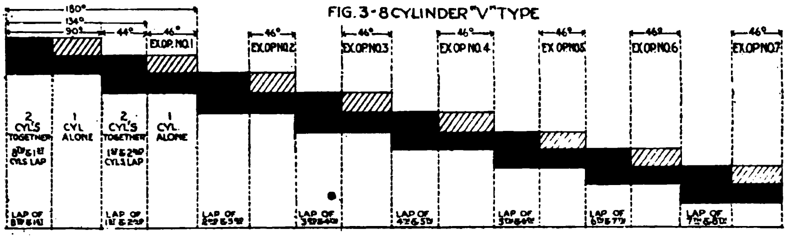
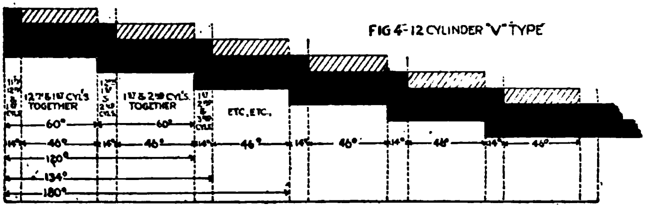


FIG 4-12 CYLINDER "V" TYPE



Eight Cylinder Lap.

The eight cylinder V type with cylinders 90° apart; when one cylinder is firing it travels the same as the four; 134° on power when the exhaust starts to open, say at 46° before bottom of its 180° stroke.

The second cylinder starts to fire 90° after the first, and moves for 134° before its exhaust valve starts to open.

Therefore there are, during the four strokes, 8 periods of 44° travel that two pistons are working together. 8 periods of 46° travel when one piston is working alone. Therefore 22/45 of the time two cylinders are working together and 23/45 of the time one cylinder is working alone.

12 Cylinder Lap.

The 12 cylinder V type or twin six; when one cylinder is firing it travels the same as those previously described; namely; 134° before the exhaust valve opens, it then continues on for 46° more, till it reaches the end of its exhaust stroke.

When the first cylinder fires, and piston has traveled only 60°, the second cylinder fires and joins No. 1; they then work together for a period of another 60° when the third cylinder fires and joins No. 1 and 2. Now No. 1 has still 14° to travel yet before its exhaust valve opens, so consequently the 3 work together until that occurs.

At the 134° point No. 1 cuts out and Nos. 2 and 3 work together for a period of 46° when No. 4 fires and joins them and so it continues throughout the cycle.

CHART NO. 58—Illustrating the "Lap" of Power Strokes of a 4, 6, 8 and 12 Cylinder Engine, the 8 and 12 being of the "V" type. Note, the above diagrams are based on the theory that the exhaust opens 46° before bottom. Also note that diagrams are not drawn to scale.

*The Eight Cylinder "V" Type Engine.

Advantage of multiple cylinder engines: "flexibility" of control, meaning quick acceleration or quick pick up of the engine from slow to fast speed, the absence of gear shifting, and a more perfect control are the features of the six, eight "V" and twin six engines. The more cylinders firing or lapping, the more flexible the control.

The eight cylinder engine is commonly known as an engine with eight cylinders placed consecutively in line over a crank shaft having eight "throws" or crank pins.

The simplest arrangement of eight cylinders would be all in line just as the six or the four are arranged. But this would be impracticable, due to the extreme length and also to the abnormally long crank shaft which would be necessary, while the crank case for such an engine would be very heavy. To get around these difficulties the cylinders are arranged in **two sets of four opposite to each other at an angle of 90° in the form of a V.**

Crank shaft: Arranged in this way, the eight cylinder engine is no longer than a four cylinder one of equal bore. As compared with a six, it has about 30 per cent less length, resulting in a shorter crank case—a weight reduction factor. In addition, its **crank shaft is of the same form** as that of a four, the throws being all in one plane; whereas those of a six crank shaft are in three planes, and is a simpler manufacturing job. Furthermore, the shorter shaft is less given to periodic vibration. The cam shaft is also shorter and less prone to whipping.

Cylinder and connecting rod arrangement: Where cylinders are "**opposite,**" this means the conecting rod lower end is attached together as shown on page 129, and termed, "**yoked**" together. The connecting rods on one cylinder in line with connecting rod on opposite cylinder. Where cylinders are "**staggered,**" this means the lower end of connecting rods are not together but are "**side by side**" on the same crank shaft bearing, (fig. 7, page 74). This naturally necessitates the cylinders on one side, being placed a little to the side, or not exactly in line with opposite cylinder, and termed "staggered."

The cam shaft on the eight V engine may be one or two, the majority use one cam shaft. The Cadillac uses a cam shaft with eight cams operating the sixteen valves, whereas the Cole and King eight V engines, use one cam shaft with sixteen cams; one for each valve.

Lap of power strokes of an eight cylinder "V" type engine: The explanation of the lap of the firing impulses is given in chart 58. This shows that during eight periods of 44° travel, there are two cylinders working together on power, whereas on a six, there are six periods of 14° travel, when two cylinders are working together.

This chart also shows eight periods of 46° travel, when only one cylinder is working alone, whereas in a six there are six periods of 106° travel where one cylinder is working alone.

There are eight power impulses or explosions, during each cycle of two revolutions of the crank shaft. In other words the four strokes or two revolutions, is just the same as, in a four, but there are **eight** power impulses or explosions during these **two** revolutions. There is a power impulse every quarter turn (90° movement) of the crank shaft, and thus there is no intermission between them, but rather an "overlapping" so complete that the turning effort is practically constant.

In the six cylinder engine, there is a power impulse every one-third revolution of the crank shaft, and though there always is a turning effort upon the crank shaft, it has more fluctuation, due to the longer interval between impulses.

In the four cylinder engine, an impulse occurs every half revolution, and obviously there are periods in the cycle when there is no appreciable force exerted by any of the pistons. The fly wheel then is called upon to carry the shaft over these power lapses.

The Cadillac Eight.

As an example of an eight cylinder engine and its construction, the Cadillac make will be shown in the charts following.

Although a later model Cadillac is model 55, and 57, the model 51 and 53 will be shown in order that the reader may note the variance in construction or improvements. The improvements of the model 55 are mentioned.

---

*See page 543; "Specifications of Leading Cars" and "Standard Adjustment of Leading Cars" for cars with eight cylinder engines.

Cadillac 1918, model 57 engine; 8 cylinder "V" type engine is same bore and stroke as formerly; 3⅛" bore by 5⅛" stroke; piston displacement 314 cubic inches. Cylinder heads now detachable. It is no longer necessary to remove radiator to take out water strainer between radiator and water pump. See page 40 for Cadillac clutch and pages 130 and 730 for water thermostat and condenser.

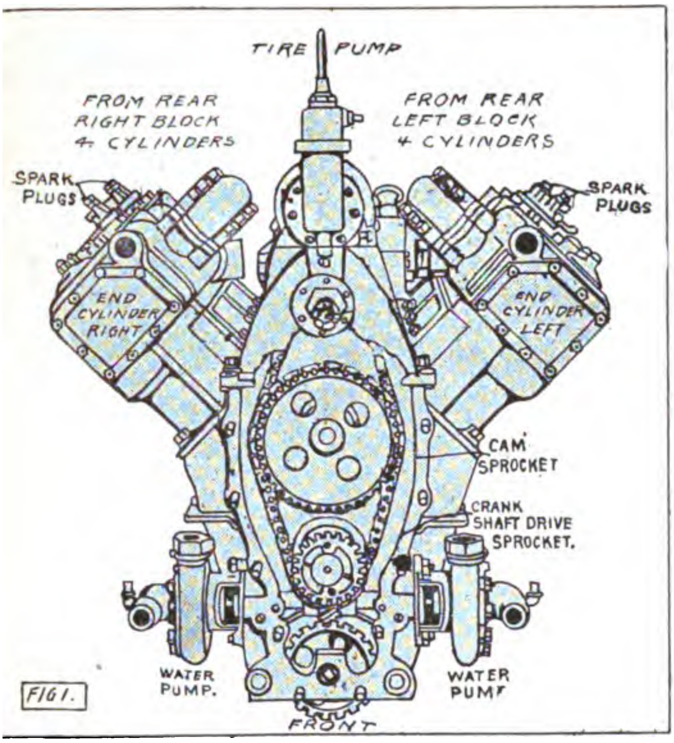


FIG 1.

****Fig. 1. Illustration shows the front end of the Cadillac eight cylinder engine. There are two groups of cylinders, each a block casting of four cylinders, mounted at 90 degrees to each other on an aluminum crank case. The cylinders are 3⅛ inch bore and 5⅛ inch stroke. The piston displacement is 314 cubic inches; the horsepower rating is 31.25. In dynamometer tests the engine shows 70 horsepower at 2400 r. p. m.. The crank shaft is indentical in design with that used in a four cylinder engine, and the cam shaft carries the same number of cams as in a four cylinder design. This engine weighs approximately 60 pounds less than the four cylinder Cadillac engine of equal horsepower. There is but one carburetor used,—explained further on.**

Each of the two cylinder castings contains four L-shaped cylinders. The intake valves are tulip shape*.

The exhaust valves are conventional poppet shape. Over each cylinder bore is a removable cap which gives access to the water jacket and to the combustion chamber. Between the second and third cylinder in each block the †breather pipe is brought up through the cylinder casting. In rear of the fan is the power tire pump for tire inflation.††

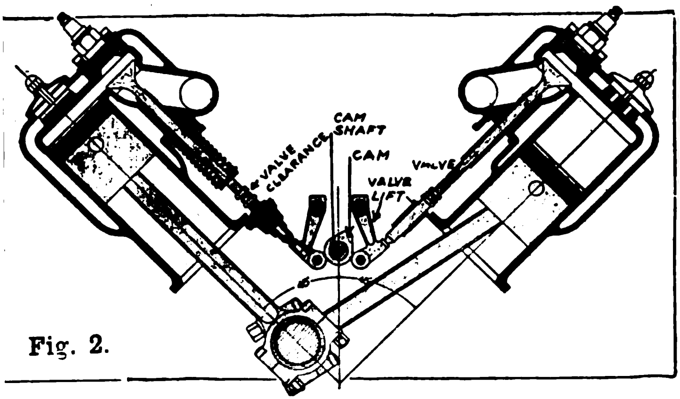


Fig. 2.

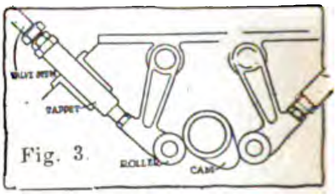


Fig. 3.

Fig. 2. Cross section of Cadilac eight cylinder engine with the cylinder mounted in two groups of four cylinders each at an angle of 90 degrees. The single cam shaft is located direct above the crank shaft, and the means whereby one cam operates the two intake valves for the opposite cylinders is shown.

Fig 3. The valve operating mechanism of the Cadillac engine, showing how one cam operates two opposite valves. The cam bears against the rollers in the ends of the small arms, which are pivoted to the plate above, and which are interposed between the ends of the push rods and the cams, so that the lift will be straight upward instead of having a side thrust component. Adjustment of valve clearance is obtained in the usual way by lengthening the tappet. The upper part of the tappet screws into the lower and the two are locked by a nut. The position of the cylinders, make the valves extremely accessible.

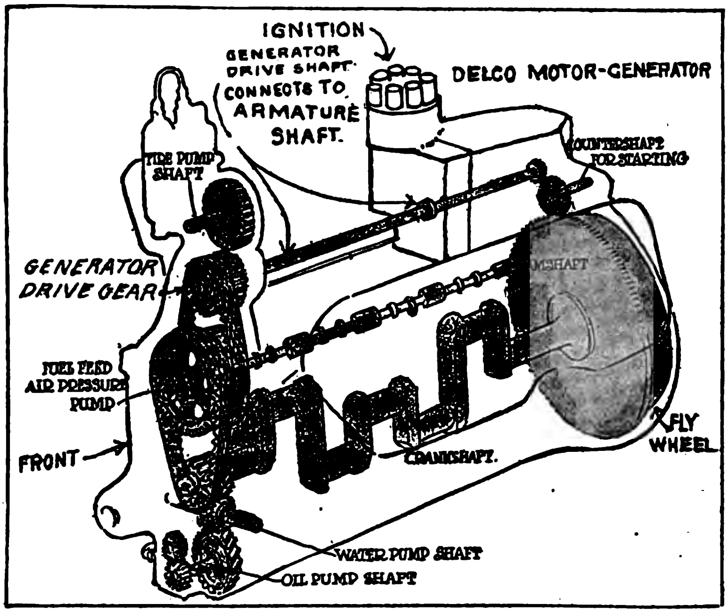
---

*Note: The tulip shaped inlet valve was used on some of the early model 51 cars, but not on other models.

†On the type 51 and 53 the engine breathers are between the second and third cylinders on each side and serve also as fillers for oil. On Type 55 breathers are on valve cover plates; and oil fillers are as in Types 51 and 53.

††The air compressor is now bolted to right hand side of transmission case and driven by a sliding gear in constant mesh with gear.

ee foot note bottom of page 127.



Shafting system in the Cadillac eight cylinder engine, showing the use of two silent chains, one driving the cam shaft and another driving from the cam shaft to the shaft driving the Delco system. The tire pump is driven by spur gear. There are two water pumps on the cross shaft below the crank shaft, and this shaft in turn drives the gear oil pump indicated.

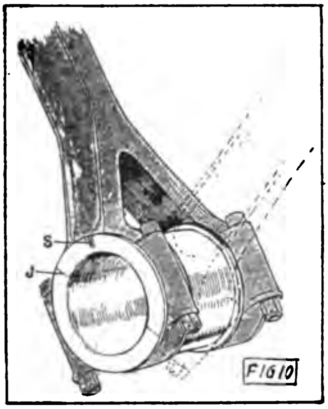
Note the single cam shaft used in eight cylinder Cadillac engines. On it are eight cams which operate the sixteen valves (eight inlet and eight exhaust valves). Each cam works two valves through the rollers shown on opposite sides of it, (fig. 3, page 128.) The shaft is caried on five bearings.

Another make of "V" type engine: The Davis, uses two cam shafts. This permits the direct opening of valves without the rocker arms which are shown in fig. 3 page 128, between cams and tappets. Also permits any desired timing.

The timing of the Davis is as follows:

Inlet opens 10° after top and closes 30° after bottom. Exhaust opens 45° before bottom and closes 5° after top.

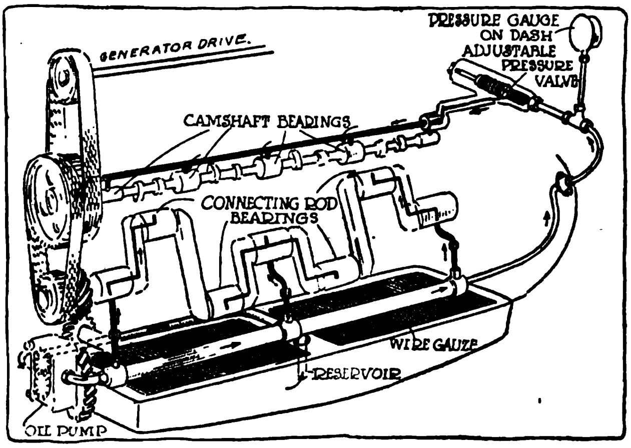
See page 132 for Cadillac **ignition timing.**



Showing how the two connecting rods are attached to one bearing. The outer rod fastens to the outer ends of the split bushing (J) with a two-bolt cap for each arm of the yoke.

The bushing is fixed to this rod by pins. The other rod goes between the two arms of the yoke, as shown by the dotted outline. This inner rod is free to move on the bushing. Therefore, the bearing for the yoke end rod is the inner surface of the bushing against the shaft, while that of the inner rod is the outer surface of the bushing.

Crank shaft: A three-bearing crank shaft is used, with the throws at 180 degrees, as in a four cylinder design. (See fig. 5, page 78; connecting rods are "yoked" however.) Two connecting rods attach to each crank pin, this being possible by having one connecting rod with a split or forked lower end, and the other a single end to fit between the forks called "yoked" design.



Lubrication of the eight cylinder Cadillac engine: The pump draws the oil up from the reservoir and forces it through the pipe running along the inside of the crank case. Leads run from this pipe to the crank shaft main bearing and thence through drilled holes in the shaft and webs to the rod bearings. It also is forced from the reservoir pipe up to the pressure valve which maintains a uniform pressure above certain speeds, and then overflows from this valve to a pipe extending parallel with and above the cam shaft. Leads from this latter pipe carry the oil by gravity to the cam shaft bearings and chains. Pistons, cylinders, etc., are lubricated by the overflow thrown from the rods.

CHART NO. 60—Parts of the Eight Cylinder "V" Type Engine (Cadillac); Crank shaft, Connecting rods, Lubrication (model 51). The models 53 and 55 are similar. See separate arrangement of generator and distributor on page 132.

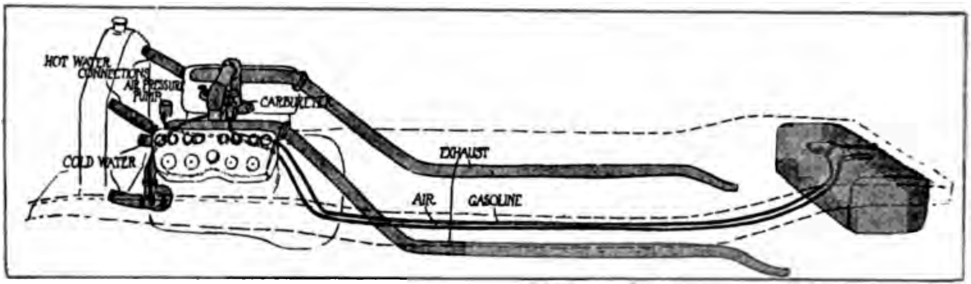


Fig. 3. Diagram showing the general arrangement of the fuel, water and exhaust systems of the Cadillac chassis. There are two exhausts and two mufflers, one for each set of cylinders; while the gasoline is fed by pressure to the carburetor which is between the two cylinder blocks. The air pressure pump for forcing the fuel is at the front of the engine. There are two water pumps and two sets of water connections to the radiator.

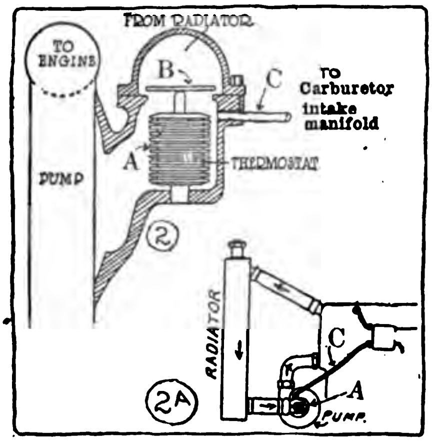


Fig. 2.—*Thermostat principles of water control: A housing containing a syphon thermostat and a **valve** controlled by the thermostat, are located on the cover of each water pump.

The thermostat (A), fig. 2, is accordion shaped. It contains a liquid which is driven into gas when heated. The resulting pressure elongates or expands the thermostat, forcing the valve (B) from its seat.

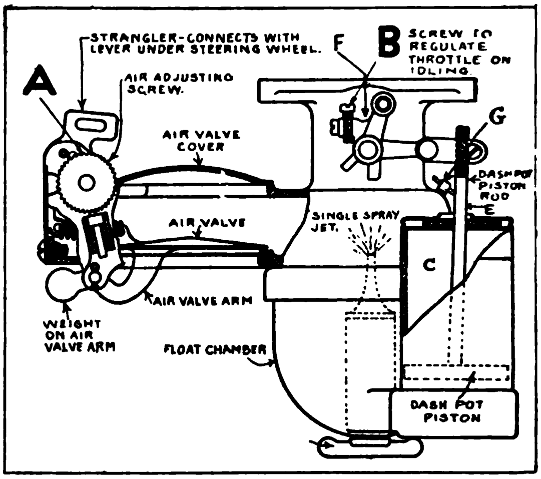
A drop in temperature changes the gas back to a liquid, reducing the pressure in the thermostat and allowing it to contract, thereby bringing the valve (B) back to its seat.

This valve on thermostat is placed in the line of circulation of water, to the side of pump (2A). When cold, the thermostat valve (B) is closed thereby stopping circulation. When warm it expands and opens valve (B) which permits pump to draw water from radiator.

A hand control connected with a shaft extending from cover of pump, is also provided from seat, which can raise this valve, in order to drain radiator.

On the Cadillac model 55 and 57, the water circulation pipe (C) is through jacket of inlet manifold. On the Packard this thermostat is placed directly at top of radiator (rear) and principle is the same.

Condenser as used on Cadillac—see page 730.



To adjust carburetor: 1—Open the throttle about 2 inches on the steering wheel. Place the spark lever in the "driving range' on the sector anl start the engine. 2—Run the engine until the water jacket on the inlet pipe is hot.

3—Move the spark lever to the extreme left on the sector and the throttle lever to a position which leaves the throttle in the carburetor slightly open. Adjust the air valve screw "A" to a point which produces the highest engine speed (see note 2).

4—Close the throttle (move it to the extreme left on the sector) and adjust the throttle stop screw "B" to a point which causes the engine to run at a speed of about 300 revolutions per minute. The spark lever should be at the extreme left on the sector when this adjustment is made.

5—With the spark and throttle levers at the extreme left on the sector, adjust the air valve screw "A" to a point which produces the highest engine speed.

Dash pot principle: The cylinder "C" on the carburetor bowl contains a plunger operated by the throttle by means of the connecting rod "F." When the throttle is opened, the plunger is forced into the gasoline in the carburetor bowl. The plunger is drawn out of the gasoline when the throttle is closed. The object of this "throttle pump" or dash pot is to force gasoline through the spraying nozzle when the throttle is opened quickly for acceleration and to assist in starting in extremely cold weather. When the throttle is opened slowly, the plunger has practically no effect on the amount of gasoline passing through the spraying nozzle.

Note 2.—Turning adjusting screws "A" or "G" in a clockwise direction increases the proportion of gasoline to air in the mixture. Turning either in a counter clockwise direction decreases the proportion of gasoline to air.

HART NO. 61—Cadillac Carburetion. Thermostat. (Model 51, 53 and 55 cars.)

See pages 187 and 188.

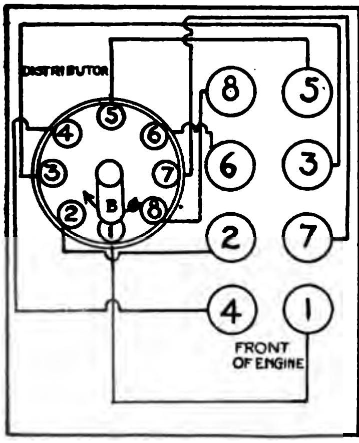


Fig. 1: Distributor connections.

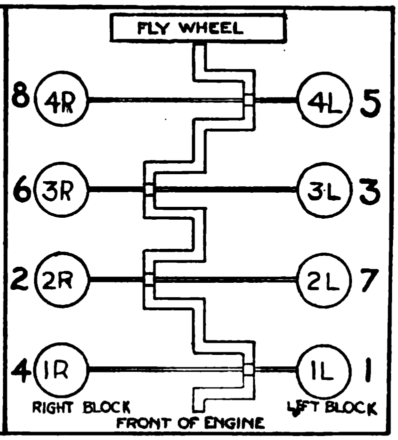


Fig. 2: Firing order.

Fig. 1: Distributor connections on the model 53, 55, Cadillac—Delco ignition system. The cables lead from connections on distributor to the cylinders in the order which they fire. Note the brush "B" makes contact consecutively, but cables from the distributor are connected to the plugs in their respective firing order.

Fig. 2: Firing order of Cadillac Model 53 **and** 55. Cylinder marked (IL) fires first, **then 2R, 3L, 1R, 4L, 3R, 2L, 4R. Or follow out the black figures on the side of cylinders which show consecutively how cylinders fire.**

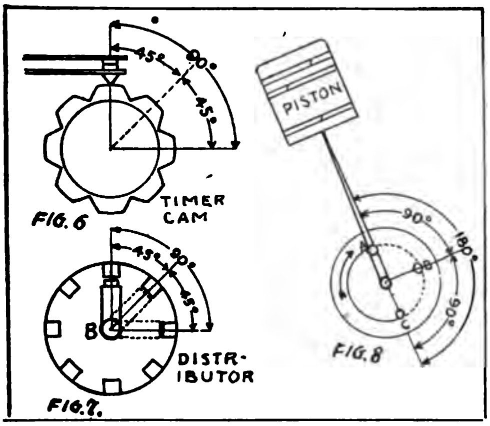


Fig. 6, 7 & 8; Cadillac—Delco distributor and Timer—movement shown in degrees. **There is an impulse or firing spark at every 90° movement of crank shaft, which is ½ of a stroke of piston, or ¼ of a revolution of crank.**

When crank travels 90°, the timer or distributor brush (B), being run at cam shaft speed, then moves 45°.

When crank makes two revolutions or 720° the timer and distributor brush (B) moves 360° or one revolution. (See Delco system for explanation of the ignition system used on this engine.)

Therefore there are 8 sparks to two revolutions of crank.

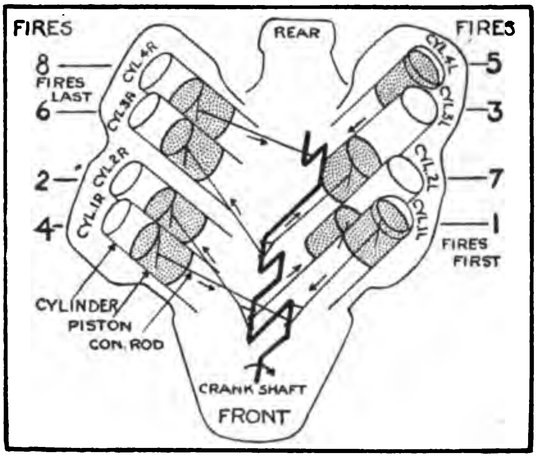


Fig. 10: Relative movement of pistons: By observing piston No. 1, which is now ready to start down on its power stroke or just commencing its working stroke, it can be seen just what is taking place in all the other cylinders, by referring to the following:

1L—Starting to fire.
3L—Starting to compress.
4L—Starting suction.
2L—Starting to exhaust.
2R—Compressing.
1R—Suction.
3R—Exhaust.
4R—Working.

Two pistons on the right (when facing engine), are all the way up and two all the way down, while all four on the left are midway.

CHART NO. 62—Cadillac Eight Cylinder V Type Engine. Firing Order and Relative Movement of Pistons, also the Distributor to Crank Shaft. (Model 53 and 55 car.)

***See foot note on page 134 explaining which is the right side of an automobile or engine.**

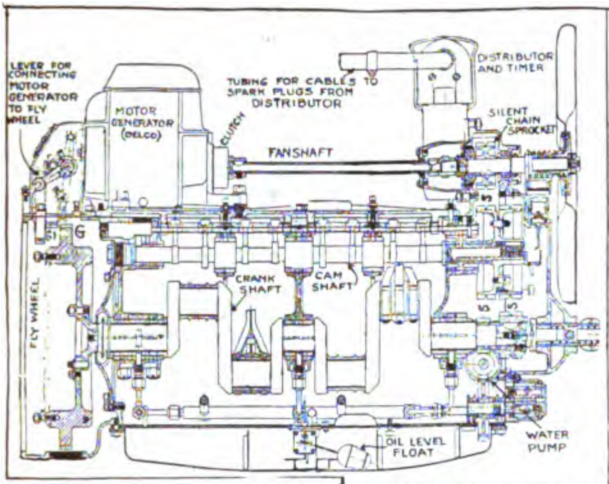


FIG. 9 - SIDE VIEW NOTE SEPERATE LOCATION OF MOTOR-GENERATOR AND DISTRIBUTOR MODEL 53

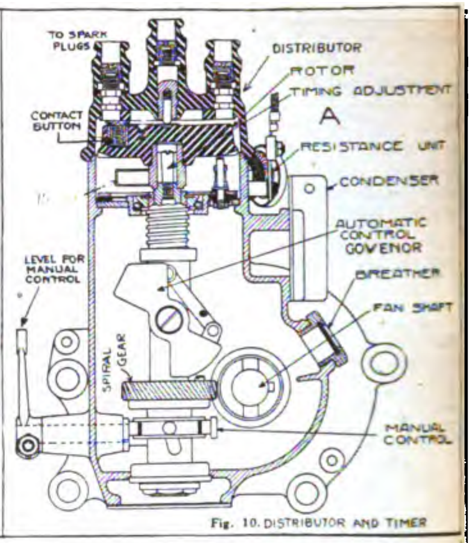


Fig. 10. DISTRIBUTOR AND TIMER

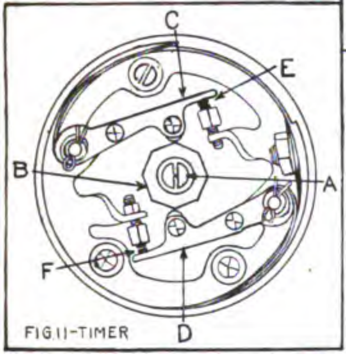


FIG. 11-TIMER

Cadillac Ignition System.

The distributor and timer (fig. 10) are carried on the fan shaft housing, and are driven through a set of spiral gears attached to the fan shaft. The distributor consists of a cap or head of insulating material, carrying one contact in the center with eight additional contacts placed at equal distances about the center and a rotor which maintains constant communication with the center contact.

The rotor carries a contact button which serves to close the secondary circuit to the spark plug in the proper cylinder.

Beneath the distributor head and rotor is the timer. The timer cam is provided with a lock screw in the center of the shaft. (See fig. 11.)

A manual spark control is provided in addition to the automatic spark control. The manual spark control is for the purpose of securing the proper ignition control for variable conditions, such as starting, differences in gasoline, weather conditions and amount of carbon in the engine. The automatic control is for the purpose of securing the proper ignition control necessary for the variation due to engine speed alone.

The timer contact points are set as follows: Turn the engine over until the contact arms "D" & "C" are directly on top of lobes of the cam "B." Then adjust the contact points at "E" and "F" so that they stand twenty-thousandths of an inch apart. Both sets of contact points should be adjusted alike.

The object for using two contact points on the timer is to distribute over two sets of points the current which would otherwise pass through one. This greatly lessens wear and burning of the points. Interrupter is the closed circuit type.

To time the ignition proceed as follows: Move the spark lever to the extreme left on the sector; open the compression release cocks on the cylinder blocks, and crank the engine by hand until the piston in No. 1 cylinder is on firing center. (No. 1 cylinder is the one nearest the radiator in the left hand block of cylinders.)

*Next remove the distributor cover; also the rotor, and loosen the lock screw A just enough to allow the cam "B" to be turned by hand after the rotor is fitted. (The lock screw should not be loosened enough to allow the cam to turn on the shaft when the engine is cranked by hand.)

Then replace the rotor and turn it by hand until the distributor brush in the rotor is directly under the terminal marked No. 1 on the distributor cover. Replace the distributor cover, and move the spark lever to the extreme right on the sector.

Then switch on ignition; hold the high tension wire to the spark plug in No. 1 cylinder about one-eighth of an inch away from the cylinder casting and turn the engine slowly by hand in the direction in which it runs. Stop turning immediately a spark occurs between the wire and the casting. (It will be necessary to turn the engine nearly two complete revolutions before the spark occurs.)

If the cam "B" is properly set a spark will occur when a point on the fly wheel one and twenty-one thirty seconds of an inch in advance of the center line for No. 1 cylinder is directly under the pointer or "trammel" attached to the crank case of the engine. This point for each cylinder is marked on the fly wheel by the letter "IG/A."

If the spark occurs before this, rotate the cam "B" slightly in a counter clockwise direction to correct the adjustment. If a spark occurs later than this, rotate the cam slightly in a clockwise direction.

After the adjustment has been properly made, lock the cam securely to the distributor shaft by the lock screw "A."

After locking the adjustment it is a good plan to check the timing by fully retarding the spark lever; in other words moving it to the extreme left on the sector, holding the high tension wire to the spark plug in No. 1 cylinder about one-eighth of an inch away from the cylinder casting, and again turning the engine slowly by hand in the direction in which it runs, stopping immediately a spark occurs.

If the ignition is properly set the spark will occur under these conditions when the center line on the fly wheel for No. 1 cylinder is directly under the pointer attached to the crank case, or has passed the pointer.

Caution: Do not set the ignition so that the spark occurs before center with the spark lever at the extreme left on the sector.

Resistance unit and ignition coil are explained on pages 378 and 246.

CHART NO. 62A—Ignition System of Type 53, 55 Cadillac—see page 396 for wiring diagram which is also wiring diagram of type 57 Cadillac.

*See page 378—adjusting Delco timer. See page 729, fig. 7, "test-light" for ignition timing.

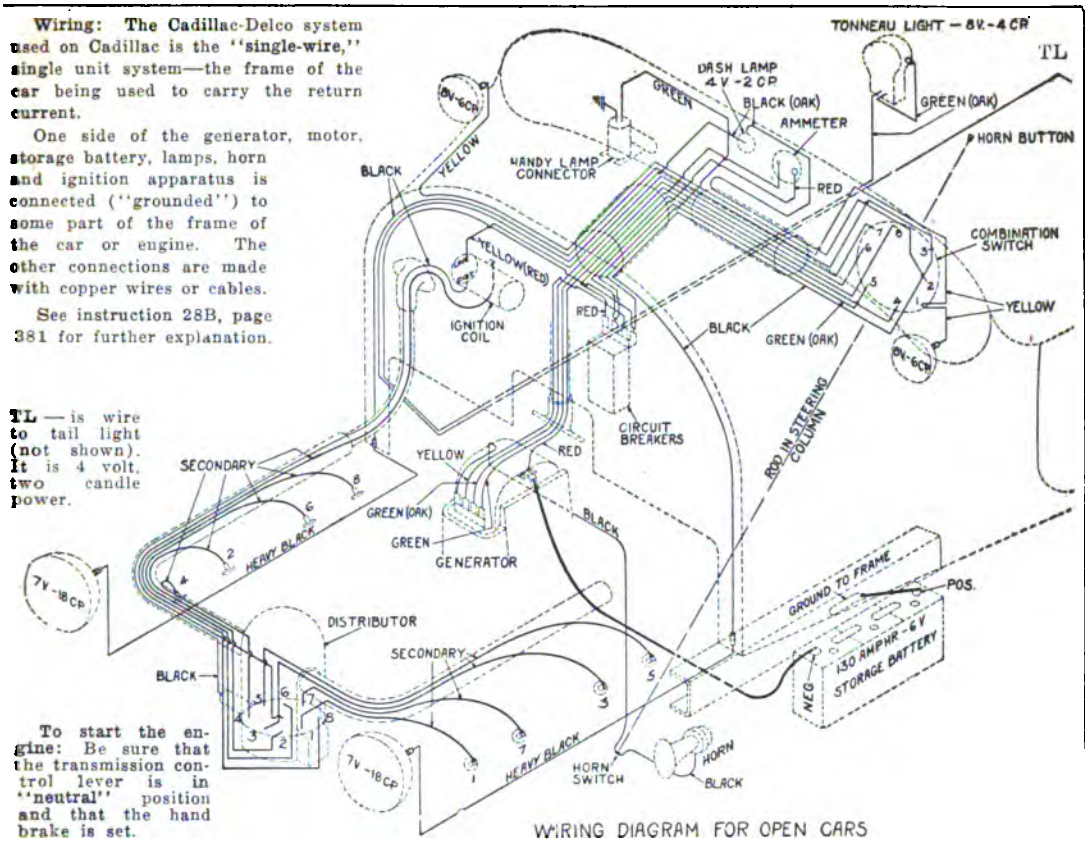
Chart 63 omitted—error in numbering.

Wiring: The Cadillac-Delco system used on Cadillac is the "single-wire," single unit system—the frame of the car being used to carry the return current.

One side of the generator, motor, storage battery, lamps, horn and ignition apparatus is connected ("grounded") to some part of the frame of the car or engine. The other connections are made with copper wires or cables.

See instruction 28B, page 381 for further explanation.

TL—is wire to tail light (not shown). It is 4 volt, two candle power.



WIRING DIAGRAM FOR OPEN CARS

To start the engine: Be sure that the transmission control lever is in "neutral" position and that the hand brake is set.

Note the pressure of air in the gasoline tank. (This is indicated by the "**air pressure guage**" on the dash.) If the pressure is less than one pound, it should be increased to that pressure by means of the "**hand air pump.**" After the engine is started the pressure is automatically maintained.

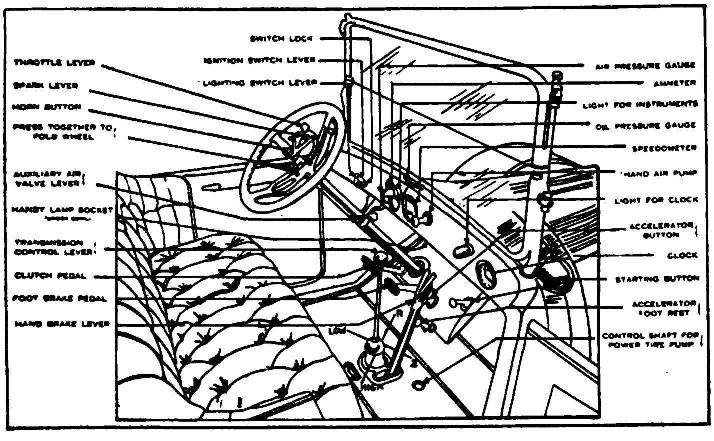
Place the spark lever in the "**driving range**" on the sector and the throttle lever about two inches from the extreme left (see note). Move the ignition switch lever down, thereby switching on ignition. Then push down on the starting button. This will bring the starter into operation and will cause the engine to "**turn over.**"

In cool weather (also in warm weather, if the engine has been standing for some time), pull up the "**auxiliary air valve lever**" before you press the starting button.

As soon as the engine fires and commences to run under its own power, which should be in a few seconds, remove your foot from the starting button.

If the "auxiliary air valve lever" is pulled up when starting the engine, it should be "pushed down about one-half the way" **immediately the engine is started, and all the way down as soon as the engine is warm enough to permit doing so.** Note.—If you crank the engine by hand, place the spark lever at the extreme left on the sector.

In extremely cold weather, if the engine is not started in 15 or 20 seconds, remove your foot from the starting button. This will stop the cranking operation. Now open and close the throttle once or twice with the hand throttle or the foot accelerator. Do not open and close the throttle more than twice.



Cadillac Model 53 control system. Note movement of gear shift lever for speed changes.

The action which causes the engine to "turn over" is produced by a gear of the electric motor sliding into mesh with teeth on the fly wheel; similar to the meshing of the gear teeth in the transmission. When pushing down on the starting button to throw these gears into mesh, if it should happen that they are in just such positions that the ends of the teeth of the starting gear come against the ends of the teeth on the fly wheel instead of the teeth of one sliding between the teeth of the other, do not force them. Simply remove your foot from the starting button and again push down on the button. In the meantime the gears will probably have changed their relative positions sufficiently to allow the teeth to mesh. **Do not press the starting button while the engine is running.**

CHART NO. 64—Cadillac Control System and Wiring Diagram—Model 53, 55 Eight Cylinder Car
(See instructions No. 19 and 28A for Delco ignition system.)
(Chart 63 omitted; error in numbering.)

The Twelve Cylinder V Type or "Twin Six" Engine.

The twelve cylinder engine is referred to in this instruction, as either a "twelve cylinder" or a "twin six." Manufacturers use both terms. Literally, a twelve cylinder engine would mean a type of engine having twelve cylinders placed in line on a crank shaft having twelve throws.

The "twin six" or twelve cylinder V engine term, if we would be exact, consists of two sets of six cylinders placed at an angle of 60° over a regular six cylinder crank shaft with six "throws" of the crank.

Therefore, if the reader thoroughly understands the six cylinder engine, then it will not be a difficult matter to understand the twelve cylinder V type.

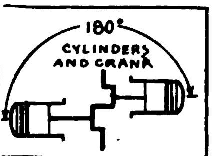


FIG5

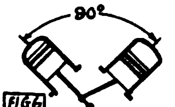


FIG6

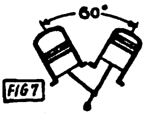


FIG7

Note the evolution of raising cylinders from 180° to 60°. **Fig.** 5 represents the old style two cylinder opposed type of engine with cylinders 180° apart. Firing impulse 360°.

Fig. 6 represents the eight cylinder engine with cylinders placed 90° apart. Firing impulse 90°.

Fig. 7 represents the twelve cylinder engine with cylinders placed 60° apart. Firing impulse every 60° of crank movement.

Before proceeding with the explanation of the "twin six," refer to the illustration, and note the different angles in which cylinders are placed.

Construction: As previously stated, by placing six more cylinders on a six cylinder crank case and placing them "V" type at an angle of 60°. The same crank shaft and practically the same crank case can be utilized without materially increasing the size or weight of engine. The extra addition being another set of cylinders and connecting rods.

On the eight cylinder "V" type, cylinders are set at an angle of 90° or ½ the distance of firing of the four cylinders. In other words a four fires every 180° and by setting cylinders 90° we get an impulse every 90°.

A six cylinder engine fires every 120°, therefore on a twelve cylinder we would place cylinders at an angle of ½ of 120° which would be 60° instead of 90° and therefore get a firing impulse at every 60° movement of the crank shaft.

The "twin six" engine offers more evenly divided impulses than the eight. Two cylinders are working together at all times and part of the time three are working together.

Firing order: The crank shaft of a twin six is of the type shown on page 122. The crank may be a right hand crank or a left hand, as explained. The firing order would be the same, that is, if you were to consider each block of cylinders on a twin six, as a separate six cylinder engine.

For instance, refer to illustration fig. 8, page 135, refer to the block of cylinders to the left, when facing engine, we will designate these as ***right hand** cylinders and will number them 1R, 2R, 3R, 4R, 5R, 6R and all on the other side we will designate as **left hand** cylinders and will number them 1L, 2L, 3L, 4L, 5L, 6L.

The figures outside of the circles, indicate the order in which the cylinders fire on the Packard twin six. 1R fires first then 6L, then 4R, 3L, 2R, 5L, 6R, 1L, 3R, 4L, 5R, 2L.

Laps of power strokes: If No. 1R fires, and crank pin moves 60°, then 6L fires and moves 60° with 1R, then 4R fires and moves 14° with 1R and 6L, at which time 1R exhaust valve opens. Therefore, making a period of 14 degrees, during which time 3 cylinders are working together.

Then 6L and 4R work together for a period of 46 degrees, after which time, 3L fires and works with 6L and 4R for a period of 14 degrees.

So that with every 60° movement of crank shaft there is a period of 14 degrees, during which time 3 cylinders work together, or in one complete revolution of crank, or 360° movement, there will be 6 periods of 14 degrees when 3 cylinders work together, and 6 periods of 46° alternating with these, when 2 cylinders work together.

The cylinders on the Packard are staggered, see fig. 8, note left cylinders set ahead of the right. This is in order that the connecting rods can be placed "side by side" on the crank pin instead of being "yoked," see fig. 5, page 78 and fig. 10, page 129.

The cam shaft: On the Packard, one cam shaft with a separate cam for each valve is used. On the National, 2 cam shafts are used.

The ignition: see Packard supplement and page 135.

***The right side of an engine or automobile is the right side, when seated in the car, that is why we number the cylinders "right" and "left," although it is the reverse when facing the front of engine. See "Specifications of Leading Cars" and "Standard Adjustment of Leading Cars" for cars using twelve cylinder engines.**

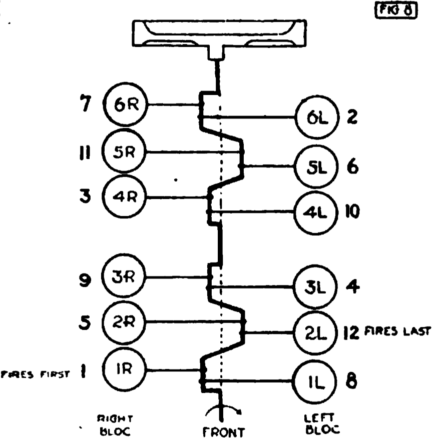


FIG 8

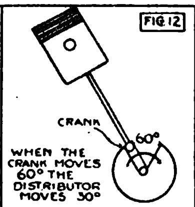


FIG 12

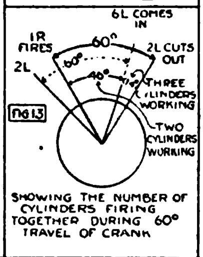


FIG 13

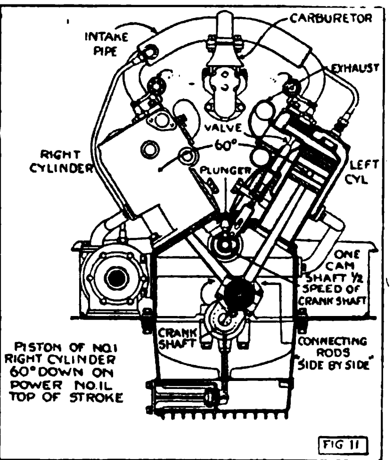


FIG 11
INTAKE PIPE
CARBURETOR
EXHAUST
VALVE
60°
PLUNGER
RIGHT CYLINDER
LEFT CYL
ONE CAM SHAFT ½ SPEED OF CRANK SHAFT
CRANK SHAFT
CONNECTING RODS SIDE BY SIDE
PISTON OF NO. 1 RIGHT CYLINDER 60° DOWN ON POWER NO. 1L TOP OF STROKE

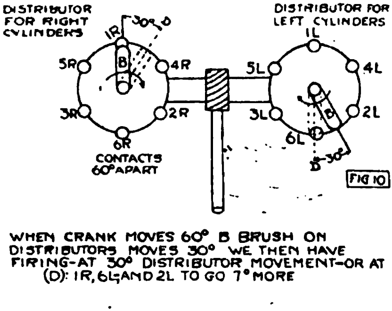


FIG 10
DISTRIBUTOR FOR RIGHT CYLINDERS
1R
30°
D
5R
4R
B
3R
2R
6R
CONTACTS 60° APART
DISTRIBUTOR FOR LEFT CYLINDERS
1L
5L
4L
3L
2L
6L
B
30°
WHEN CRANK MOVES 60° B BRUSH ON DISTRIBUTORS MOVES 30° WE THEN HAVE FIRING AT 30° DISTRIBUTOR MOVEMENT—OR AT (D): 1R, 6L, AND 2L TO GO 7° MORE

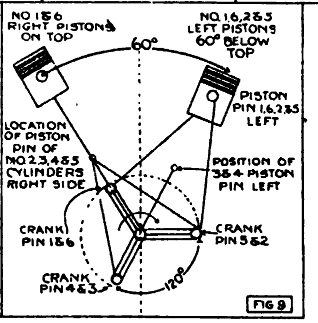


FIG 9
NO 1 & 6 RIGHT PISTONS ON TOP
60°
NO. 1, 6, 2 & 5 LEFT PISTONS 60° BELOW TOP
PISTON PIN 1, 6, 2 & 5 LEFT
LOCATION OF PISTON PIN OF NO. 2, 3, 4 & 5 CYLINDERS RIGHT SIDE
POSITION OF 3 & 4 PISTON PIN LEFT
CRANK PIN 1 & 6
CRANK PIN 5 & 2
CRANK PIN 4 & 3
120°

Twelve Cylinder Firing order: If we considered each side as a separate six cylinder engine, the firing order would be 1, 4, 2, 6, 3, 5.

Note the crank shaft; the throws 1 and 6, 2 and 5, 3 and 4 are in line. This would be a left hand crank shaft, see fig. 2, page 124.

Supposing the firing order was 1, 4, 2, 6, 3, 5, and each bloc separate, the right bloc, starting from front, would fire, **1R, 4R, 2R, 6R, 3R, 5R.** Now start at rear of left bloc, **6L, 3L, 5L, 1L, 4L, 2L.** If the cylinders were numbered from the rear, on the left bloc, as 1L, 2L, 3L, etc.; the firing order would be 1L, 4L, 2L, 6L, 3L, 5L; same as the right bloc, but from rear to front.

In order to see just when three cylinders are working together, refer to fig. 12 and 13. Suppose cylinder 1R fires; 2L will have fired just previous, therefore 1R and 2L firing strokes will run together or "lap," as it is called, for a period of 46 degrees, for this period, note 2 cylinders are working together. Then cylinder 6L will start on its power stroke and will "lap" with 2L and 1R for a period of 14 degrees (3 cylinders working together during this 14 degree period of travel of crank pin), at which time 2L cuts out.

The relation of the movements of the distributor and timer to the crank shaft: The timer and distributor revolve one-half the speed of the crank shaft, or the same speed as the cam shaft. The Packard "twin six" employs two timers and distributors, operated at the same speed as the cam shaft. There is a separate timer and distributor for each bloc of cylinders. See fig. 10 above, which is an exaggerated illustration in order to simplify the meaning.

Now suppose the crank shaft moved 60° (see fig. 12 and 13). During that period of travel we would have had two cylinders on power for a period of 46° and 3 cylinders on power for a period of 14°.

The distributor on each bloc would, each, have moved cam shaft speed (½ that of crank), or ½ of 60° or 30 degrees. We must, however, have had 2 explosions, but 3 cylinders on power, during this period; 2L fired just before 1R, therefore when piston 1R reached top of its stroke and fired, we had then traveled 30 degrees (this means 30° timer and distributor movement or 60° crank pin movement) on the power stroke of 2L. Therefore 2L continues on its power stroke with 1R, 30°; when 6L fires and the three continue to work together for a period of 7° more (timer movement, or 14° crank pin movement), (see fig. 13), when 2L exhaust valve opens and cuts out 2L, leaving 2 cylinders working together for a period of 46° when the next cylinder fires, etc.

Fig. 9: **"Throws" of crank shaft are 120° apart,** note crank pin "throws" 1 and 6, 3 and 4, 2 and 5 are in line. Crank revolving to the right, note cylinder 1R is on top and would fire, then 6L, both being in line, then 4R, then 3L, 2R, 5L, 6R, 1L, 3R, 4L, 5R, 2L.

When No. 1 and 6 right connecting rods move 60°, then 1 and 6L connecting rods will also move 60°, at which point they will be on dead center.

Fig. 11. End sectional view of the Packard twin six; cylinder 1R is 60° down on power, 6L is on dead center—see page 136 for relative position of pistons.

CHART NO. 65—Twin Six Firing Order. Relation of the Speed of Crank Shaft to Distributor.

Note word "bloc," used above, is term formerly used, should be block. See also pages 918, 920.

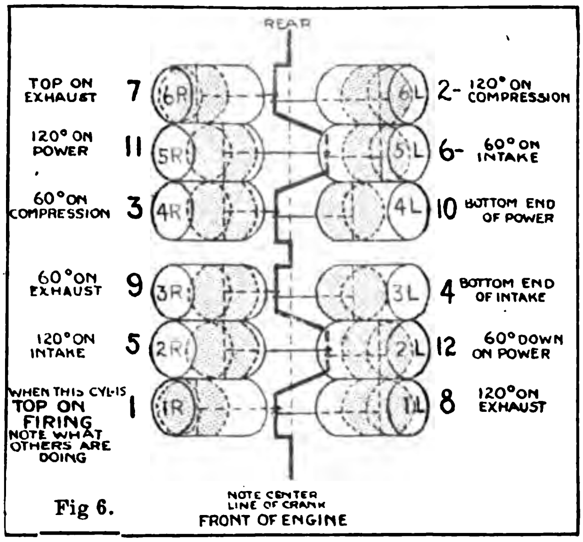


Fig 6.

Twelve Cylinder Piston Positions.

Fig. 6 illustrates the relative position of pistons and what is taking place in each cylinder when cylinder 1R is just starting its power stroke.

Just consider each block of cylinders a separate six cylinder engine and it will be easy to understand the twin six.

The crank pins are 120° apart, whereas the firing impulses are 60° apart.

Note the order in which the cylinders fire is designated by the numbers outside of the cylinders, in heavy type.

Note position of pistons when No. 1R is just ready to go down on power.

Engines with Overhead Valves and Cam Shaft.

The cam shaft on this type is placed overhead and operated usually, by a vertical shaft driven from crank-shaft. See page 137.

The aeroplane engine uses this principle extensively as will be noted by referring to pages 911 to 916. On page 916, note there are two inlet and two exhaust valves to each cylinder.

The "Sleeve Valve" Type of Engine.

The sleeve valve engine differs from any other four cycle engine, only in its method of admitting and exhausting the gas.

The sleeves: Instead of raising and lowering poppet valves, to admit and expel the gas there are two sleeves with ports or slots in them; at certain times, these slots on the same side of cylinder come in line as shown in figs. 2 and 5, chart 69. These sleeves take the place of valves.

The openings occur at the proper time, in a similar manner as any other valves are opened and closed—that is, the exhaust opens once during the four strokes and the inlet opens once during the four strokes of the piston. The sleeves of course sliding up and down cause this opening and closing.

Eccentric shaft: The sleeves are caused to slide up and down by an eccentric shaft (takes the place of a cam shaft), which has eccentrics raising and lowering small connecting rods OS & IS, see figs. 1 and 2. This eccentric shaft is driven by a chain from a sprocket on the crank shaft of engine. It is driven the same speed as any other cam shaft, ie., one-half the speed of engine crank. The eccentric pin operating the inner sleeve is given a certain lead or advance over that operating the outer sleeve. This lead, together with the rotation of the eccentric shaft at half the crank shaft speed, produces the valve action illustrated in chart 69, which shows the relative position of the piston, sleeves and cylinder ports at various points in the rotation of the crank shaft.

Valve timing: The timing shown is not different from that ordinarily used in poppet valve engines, but the valve area is greater than that of an ordinary poppet valve. The equivalent of increased valve area is gained, also, by the directness of the valve opening and the absence of restrictions in the gas passages.

Valve timing of the Stearns-Knight four cylinder—see chart 69. Valve timing of the Stearns-Knight six cylinder; the same except inlet opens 4 degrees instead of 8 degrees, and exhaust closes on top dead center instead of 4 degrees after.

Setting ignition: Set cylinder No. 1 piston on top of compression. Retard contact breaker box on Bosch magneto. Set points on interrupter just breaking. There is a mark on fly wheel which, when lined up with mark on cylinder, will show when 1 and 6 or 1 and 4 are up. Firng order on six is 1, 5, 3, 6, 2, 4 and 1, 3, 4, 2 on the four.

The "Rotary Valve" Engine.

Is divided into two classes; the "**single**" and the "**double**." See figs. 6, 9 and 10, chart 70 for description of the "single" rotary valve.

The "Rotary Cylinder" Engine.

In the ordinary motor car engine the cylinders are bolted to a crank case and the crank shaft is made to turn around by the force of the explosions in the cylinders. In the rotary "cylinder" engine the crank shaft is stationary, and the cylinders revolve (used mostly for driving aeroplanes). See chart 70.

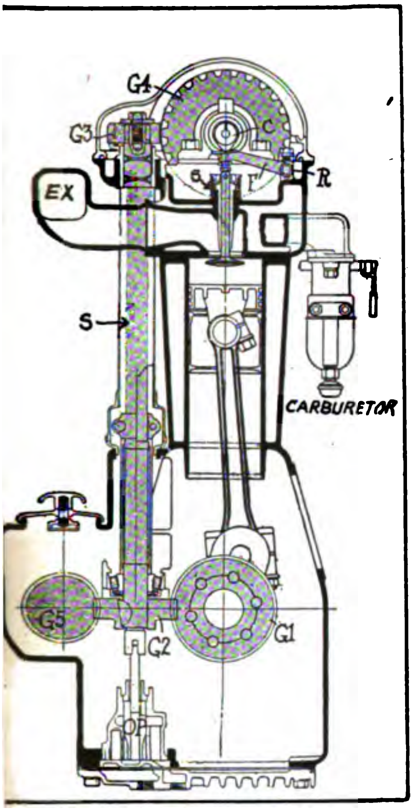


Fig. 2: **Overhead valves operated by an overhead cam shaft; the Weidley principle.**

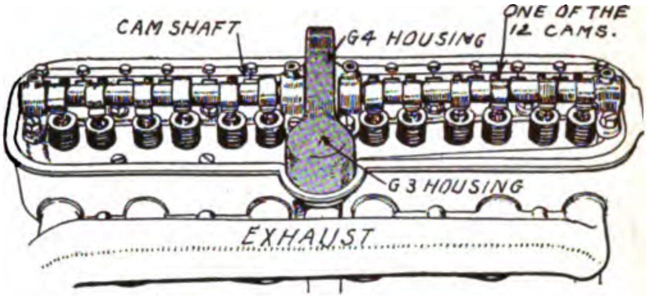
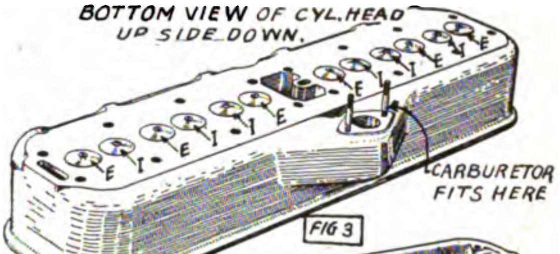
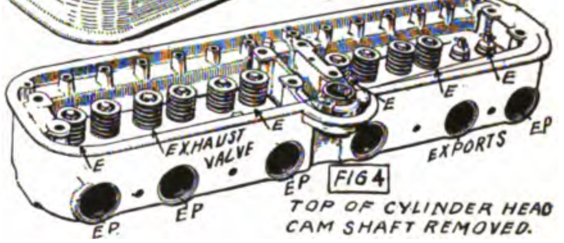


Fig. 7: Note on the cam shaft there are twelve cams operating the twelve valves..





Valves: In the types of engine previously described the valves were either all on one side or opposite, or overhead, but operated by a plunger or tappet or by an overhead rocker arm. In this type the **cam shaft is placed overhead** as per fig. 7, with the cams integral. There are two overhead valves for each cylinder—see figs. 3 and 4, therefore twelve cams, one for each valve.

Cam shaft is operated by a gear G1 on the crank shaft, which operates a gear G2, fig. 2, which is called the lower timing gear; this gear is placed at the lower end of a vertical shaft (S) with an upper timing gear (G3), which operates the cam shaft gear (G4). By referring to fig. 2, it will be seen how the cam C operates the tappet arm (F), which in turn opens the valve against the tension of the spring (S).

While the construction varies, the principle, it will be noticed, is just the same as any other engine. The cam shaft turns one revolution to two of the crank shaft.

The cam shaft mounted on the cylinder head, has four bearings and are 1 3/16 inch in diameter. The end bearings are 1¼ by 1⅜ in. long, and the middle ones, which are on either side of the driving gear are 1⅜ by 1⅝ inch long. A hole ⅝ inch diameter is drilled through the cam shaft for its entire length, and carries oil to the cams and bearings.

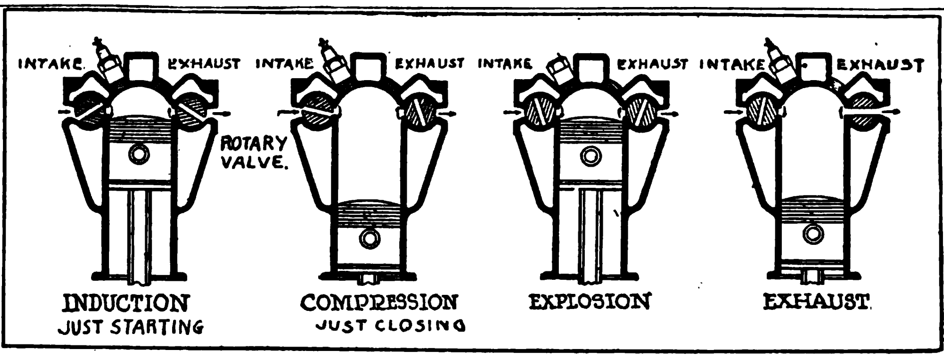
Cylinder head—in this type engine the cylinder head is detachable from the cylinder, and the cylinders are all in one block, therefore to grind the valves or to get to the valves, the cover is removed, then the cylinder head. Fig. 4, shows the cylinder head removed and fig. 3, shows the cylinder head turned up side down, exposing to view the valves seated in the cylinder head casting.

To grind valves: First, remove head. If a single valve is to be ground the valve spring may be compressed and pin holding spring removed, when valve can be dropped out and the seat ground, or the cam shaft may be removed, which is easily done. Springs and pins removed and the cylinder head turned over on a bench, as in fig. 3, and valves ground as any other valves. See index for method of valve grinding.

To set the valves: The inlet opens 10° past top and fly wheel is marked "IO." Exhaust closes at 10° after top. Therefore, set the cam shaft with piston No. 1, 10° past top center; cam just leaving exhaust valve (see C, which would be a little further in direction of rotation, as it now has valve open). The gears are then meshed at this point. The timing of both inlet and exhaust is done by one cam shaft, same as on an "L" type cylinder.

CHART NO. 66—The Overhead Valve Operated by an Overhead Cam Shaft—Weidley six cylinde as an example. Note cylinder head is detachable with valves in the head.

Note—Due to error, chart 67, has been omitted and chart 70 follows this. Charts 68 and 69 follow chart 70.



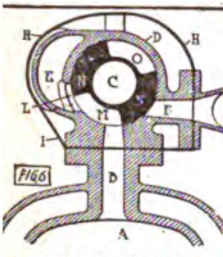


FIG 6

SINGLE ROTARY VALVE

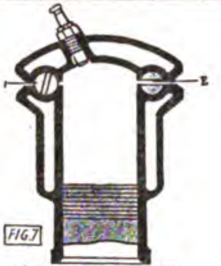
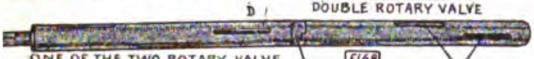


FIG 7

DOUBLE ROTARY VALVE



ONE OF THE TWO ROTARY VALVE RODS OF DOUBLE ROTARY

FIG 8

FIG 10 Shows position of the valve and the ports on the four strokes of the piston

FIG 9 .—Section through the Bournonville motor showing the rotary valve, which is made in four parts lettered C. The valve is made with a .002 inch clearance in its housing

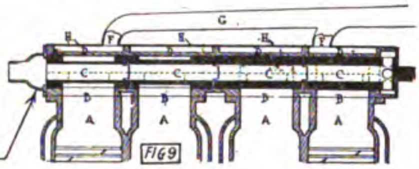


FIG 9

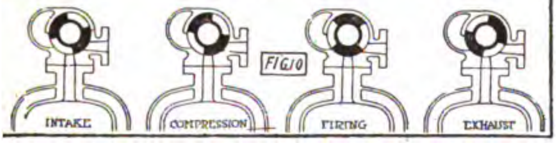


FIG 10

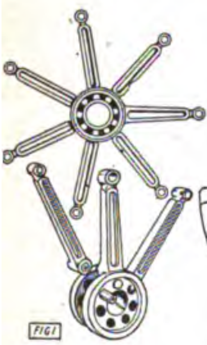


FIG 1

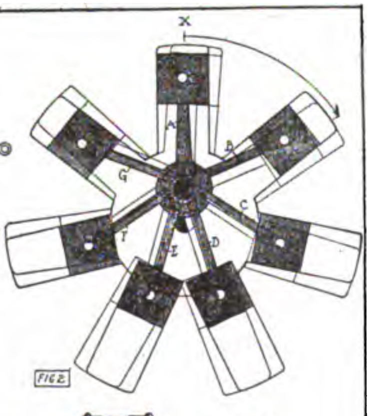


FIG 2

FIG 3

Rotary "Cylinders."

ROTARY "VALVE" ENGINE.

The cylindrical piece of metal (fig. 8) takes the place of the poppet valve and the spring and all the other poppet mechanism. It will be noticed that there are long holes in the shape of slots, S, in this rod.

These Holes are Called the Ports. The rotary-valve motor used in the Speedwell car has two of these pieces of metal, one for the intake and the other for the exhaust.

In the Poppet Motor of Four Cylinders there are four intake valves and four exhaust valves. In the rotary-valve motor, instead of having the eight there are two long rods each with four holes cut out. In other words, the holes in the rods are valves themselves.

At (D) Fig. 8, is shown a valve for three cylinders. G is a coupling connecting the two parts.

These Valves, as stated before, fit snugly into openings in the side of the cylinder, as shown in the illustrations at top of page and fig. 7.

The One Marked (I) fig. 7, may be called the intake and the other marked E the exhaust valve.

These Rods Have Gears at Their Ends and these gears are operated by a chain from another gear on the crank shaft.

This Means that the valves turn around when the motor is running. As the valve turns around the slots at some time or other are in line with the combustion chamber and at the same time with the intake or exhaust pipe, as the case may be. Now, as soon as the slot is in line, as shown on the exhaust side of the illustration at B, the gas rushed through the slot and out through the exhaust pipe. If the intake slot at that cylinder is in line then gas will rush into the cylinder just as it rushes past an ordinary poppet valve.

Fig. 7, 8 and top Illustrations show the "double" rotary valve.

Figures 6, 9 and 10 show the "single" rotary valve.

ROTARY "CYLINDER" ENGINE.

In the Rotary-cylinder Engine the crank shaft is held stationary and the cylinders are mounted on a cylindrical crank case which can revolve.

The Rods are Fastened to the Crank Shaft Pin by means of a bracket and bearing, as shown in Fig. 1.

When an Explosion Occurs in such an engine the energy can do nothing else but force the piston down. This action turns the rod holder on the crank shaft, which causes the rods, pistons and hence the cylinder to revolve as a unit.

The Pistons and Connecting Rods Turn, but since the rods are mounted on a crank and the crank is stationary, the pistons will take different positions in the cylinders owing to the location of the rods on the crank pin. By referring to Fig. 2, which shows a section of the Gnome seven cylinder rotary motor and the pistons with rods mounted, this will be clear. When an explosion occurs the cylinders and rods A, B, C., etc., all turn.

In the Movement of the Cylinder A From X to Y the piston in the cylinder will travel downward, as shown in the illustration

By the Time Cylinder A Reaches the Position Now Occupied by Cylinder B the piston will be almost at the bottom of its stroke.

In Other Words, it is really the cylindrical rod holder shown in Fig. 1, which determines the position of the pistons and this is so because the holder assumes different positions at the crank.

HART NO. 70—The Difference Between the Rotary "Valve" and the Rotary "Cylinder" Engine.

art 67 omitted; error in numbering.) See page 910 for Gnome rotary cylinder engine.

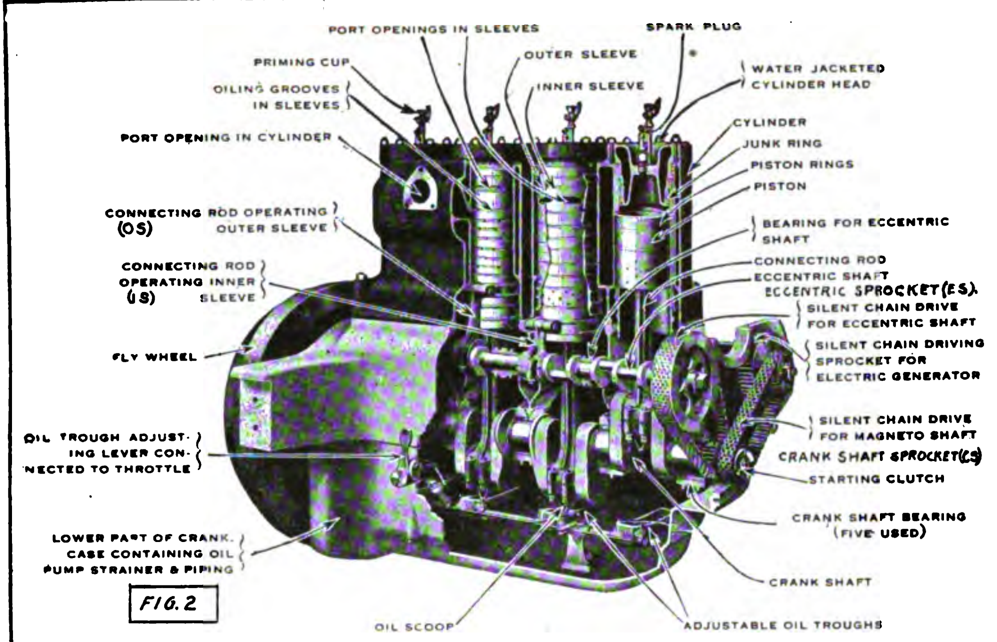

PORT OPENINGS IN SLEEVES
SPARK PLUG
PRIMING CUP
OUTER SLEEVE
OILING GROOVES IN SLEEVES
INNER SLEEVE
WATER JACKETED CYLINDER HEAD
PORT OPENING IN CYLINDER
CYLINDER
JUNK RING
PISTON RINGS
PISTON
CONNECTING ROD OPERATING OUTER SLEEVE (OS)
BEARING FOR ECCENTRIC SHAFT
CONNECTING ROD
CONNECTING ROD OPERATING INNER SLEEVE (IS)
ECCENTRIC SHAFT
ECCENTRIC SPROCKET(ES).
SILENT CHAIN DRIVE FOR ECCENTRIC SHAFT
FLY WHEEL
SILENT CHAIN DRIVING SPROCKET FOR ELECTRIC GENERATOR
SILENT CHAIN DRIVE FOR MAGNETO SHAFT
OIL TROUGH ADJUSTING LEVER CONNECTED TO THROTTLE
CRANK SHAFT SPROCKET(CS)
STARTING CLUTCH
CRANK SHAFT BEARING (FIVE USED)
LOWER PART OF CRANK CASE CONTAINING OIL PUMP STRAINER & PIPING
CRANK SHAFT
OIL SCOOP
ADJUSTABLE OIL TROUGHS

FIG. 2

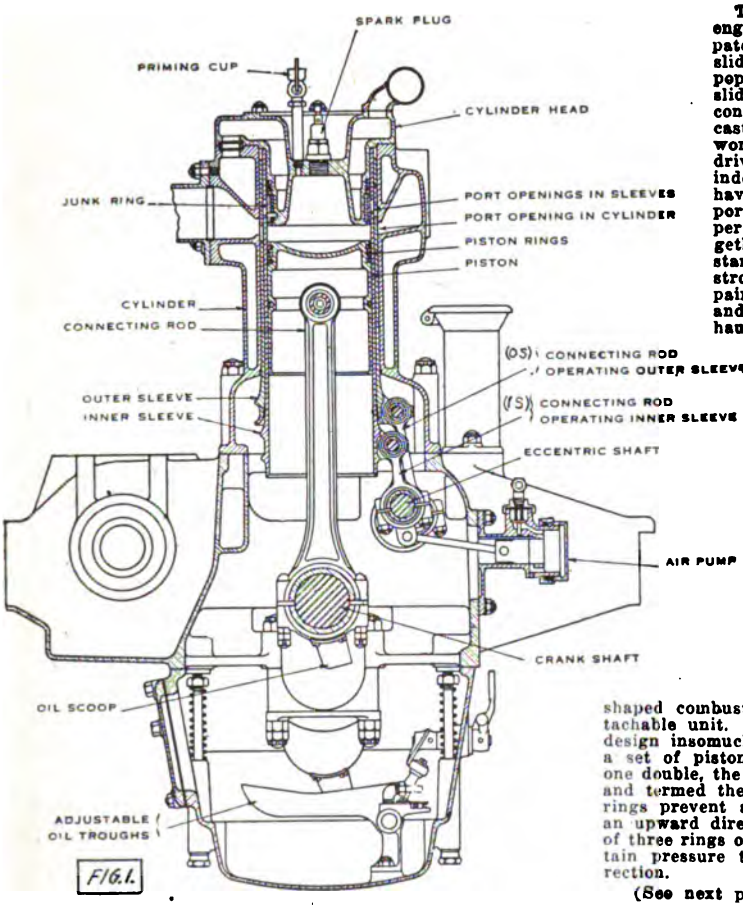


FIG. 1.

The main principle of th engine (made under Knight patent) is the substitution sliding valves for the usu poppet or tappet valves. T sliding valves consist of tv concentric shells cast iron accurately turne working in between t driving piston and the cy inder walls. These she have two series of large ar ports or slots cut in the u per ends, which register t gether at the required i stant in the respecti strokes of the piston. O pair of slots form the inle and the other pair the e hausts.

The sliding shells each cylinder, whi have a relatively sho stroke, about 1 inc are driven by tw short connecting ro or side arms worki off a lay crankshaf the cranks having very small thro which takes the pla of the camshaft in t tappet valve form engine.

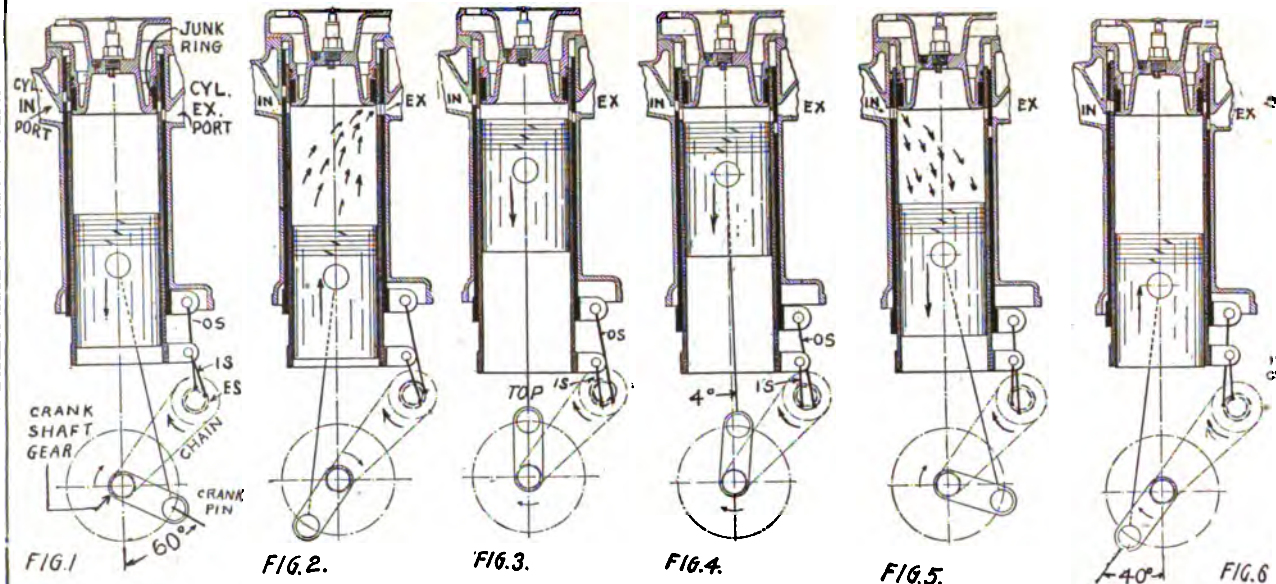
This valve-operati shaft rotates at ha the speed of ma crankshaft. The sl ing shells extend rig up into the deep con shaped combustion head, which is a d tachable unit. This head is of a spec design insomuch that it is provided wi a set of piston rings, three narrow a one double, the latter being specially wi and termed the compression ring. The rings prevent any escape of pressure an upward direction, whilst the usual s of three rings on the working piston mai tain pressure tightness in the lower d rection.

(See next page for further detail.)

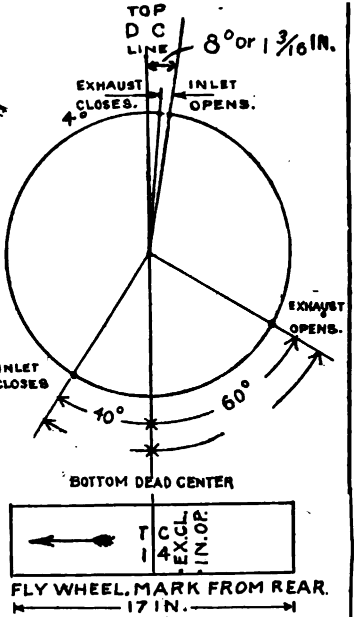
CHART NO. 68—The Knight Sleeve Valve Type of Engine, used on Stearns-Knight Car. (. see index.)

(Chart 71 on page 141.)

ART NO. 69—Stearns-Knight Sleeve Valve Engine.



KNIGHT-STEARNS 6CYL. TIMING.



KNIGHT 4 CYL. VALVE TIMING

Eccentric shaft sprocket (ES) is twice the size of crank shaft sprocket, therefore revolves ½ the speed of crank shaft, same as any cam shaft. (OS) means outer sleeve and (IS) inner sleeve eccentric rod.

The motion of the eccentric rods (OS) and (IS) are controlled by eccentric on a shaft driven by sprockets. Firing order, 1, 5, 3, 6, 2, 4. View is from front of engine. The "ports" are the openings. Note "sleeve intake and exhaust ports" are openings in sleeves, and "cylinder intake and exhaust ports" are openings in the cylinders. The eccentric pin would be the small black dot at bottom of (IS) and (OS). Note the position of this as it travels 90° when crank travels 180°.

Fig. 1. Exhaust starts to open at 60° before bottom. Toward the end of the power stroke, as in any four-cycle engine, the exhaust port is uncovered by a downward motion of both sleeves, the inner moving at a higher speed than the outer. Instead of a valve opening, the opening occurs in the sleeve.

Fig. 2. Exhaust fully open. At the starting of the exhaust opening the outer sleeve port is approximately in register with the cylinder ex. port, the full opening being obtained chiefly through the more rapid motion of the inner sleeve, its port "catching up" with the port in the outer sleeve.

Fig. 3. Exhaust closes on top. The inner sleeve first reaches the bottom of its travel (note position of eccentric rod IS), and the outer sleeve, following it, closes the exhaust opening by over-running the cylinder port.

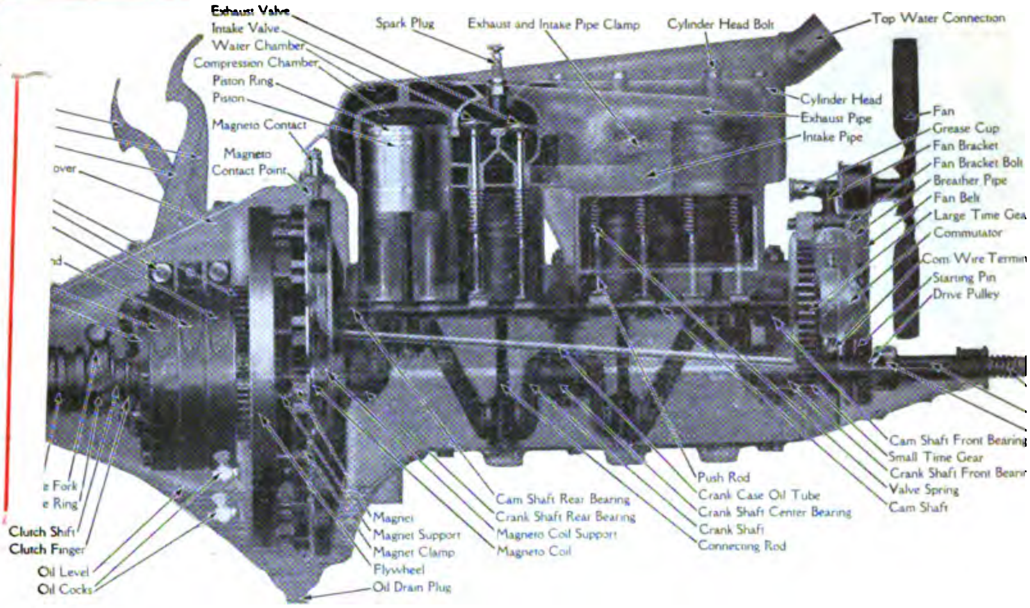
Fig. 4. Inlet opens 4° after top. At the closing of the exhaust, the sleeves are moving in opposite directions, the inner one up and the outer one down (see eccentric OS and IS above). The inlet ports in the sleeve then overlap, the opening being in line with the cylinder wall. Inlet ports in the sleeves are moving in opposite directions.

Fig. 5. Inlet full open. The continued but slow downward movement of the outer sleeve, together with the increasingly rapid upward motion of the inner, causes the two sleeve ports to coincide with each other.

Fig. 6. Inlet closes 40° after bottom center. From the point of full inlet opening, both sleeves travel upward, the inner at a higher rate than the outer. This action is continued until cut-off is secured and the port closed by the lower edge of the inner sleeve port over-running the lower edge of the "junk" ring carried by the head casting of the cylinder.

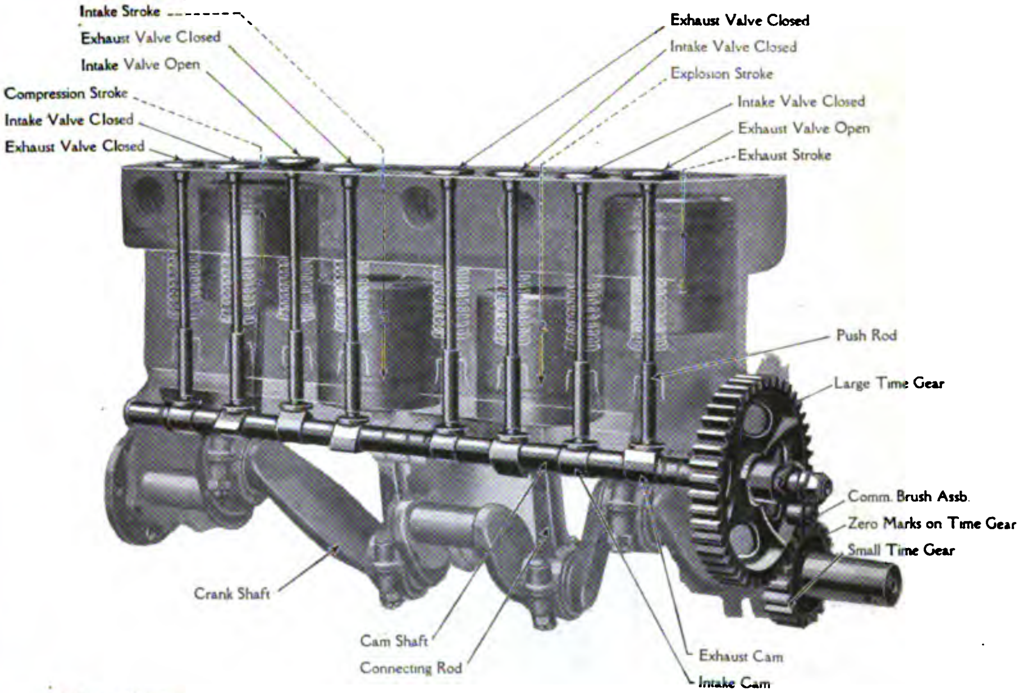
As the inlet closes, the next stroke up would be the compression stroke, and when on top the explosion would occur and piston would **go to position** shown in fig. 1.

Copyrighted 1918, 1919, by A. L. DYKE, St. Louis, Mo.



Ford Single Unit Power Plant Model "T" Engine.

Consisting of Engine, Transmission with Clutch and Magneto—all in one unit. By referring to pages 784, 777, 783 and 775, the description of parts designated can be found.

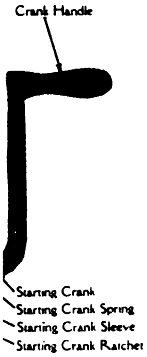


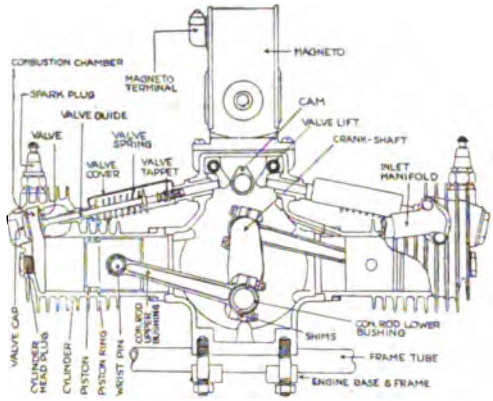
Above illustration gives a good view of the relation of the Ford crankshaft and small timing gear which drives the camshaft through the large timing gear, also the camshaft, cams and valves. As the large timing gear is twice the size of the small driving gear the camshaft will, of course, revolve one-half the speed of crank shaft.

The firing order is 1, 2, 4, 3. No. 1 cylinder is next to the gears, or front of engine. **No. 2 piston is going down (see arrow point) on explosion stroke.** Note the nose of cam does not raise either of the valves, therefore intake and exhaust valves are closed; **No. 4 piston is almost at top of its compression stroke** and will be the next cylinder to fire and piston will then go down on explosion stroke. Note both valves are closed. **No. 3 piston is going down on intake stroke,** drawing in a charge of gas, as inlet valve is open, but exhaust valve is closed. Piston of No. 3 will go up on compression stroke at which time inlet valve will be closed and will fire after No. 4; **No. 1 has almost completed its exhaust stroke.** Exhaust valve is open. Intake valve is closed. Immediately that exhaust valve closes, which is exactly on top, then the inlet valve will open and it will go down on intake stroke next, then compression stroke up, then explosion stroke, therefore No. 1 will fire after No. 3. See also page 784 and 785.

*Indian Twin-Opposed-Cyl. Motorcycle Engine.

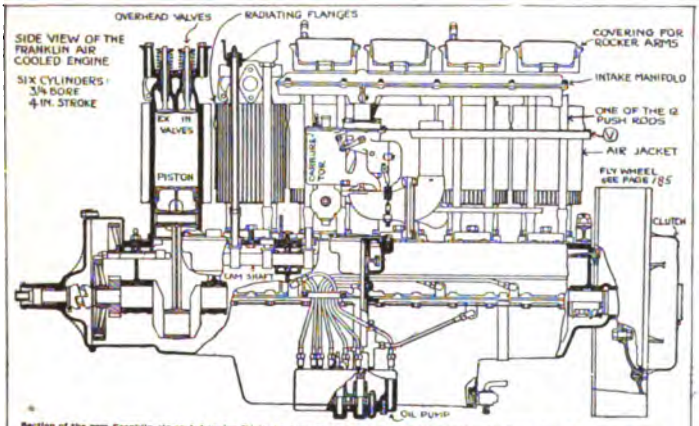
Cylinders; two, opposite or 180° apart instead of 42° as in the V engine. See page 118, explaining firing orders of this type of engine. **Bore** 2 inch; **stroke** 2½ inch; **piston displacement** 15.70 cubic inches; **H. P.** normal rating 2¼, develops 4. **Pistons** have two **rings**; **inlet and exhaust valves** side by side on top of cylinders; **timing gears** in separate **housing** outside of crank case; **carburetor**; Indian special; **ignition**, Dixie magneto driven at **engine** speed—**fixed or set spark.**



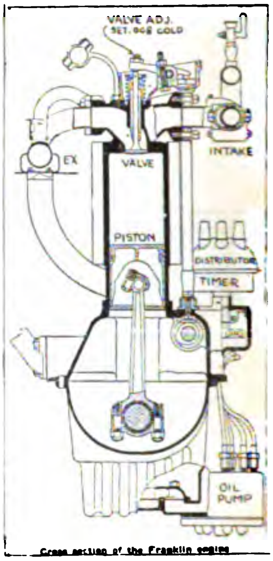


Addresses of Some of the Leading Engine Manufacturers.

Lycoming Foundry & Machine Co., Williamsport, Pa., "Lycoming."
Sterling Motor Co., Detroit, Michigan, "Sterling."
Hershell-Spillman Co., North Tonawanda, N. Y.
Rutenber Engine Co., Marion, Ind.
Northway Motor Mfg. Co., Detroit, Mich.
Falls Motor Corp., Sheboygan Falls, Wis.
Ferro Machine & Foundry Co., Cleveland, O.
Golden Belknap & Swartz Co., Detroit, Mich.
Waukesha Motor Co., Waukesha, Wiscn.
Buda Co., Harvey, Illinois.
Beaver Mfg. Co., Milwaukee, Wiscn.
Brennan Motor Mfg. Co., Syracuse, N. Y.
Weidely Motor Co., Indianapolis, Ind.
Teetor-Hartley Motor Co., Hagerstown, Ind.



Section of the new Franklin air-cooled engine 3¼ in. by 4 in. This is on much the same lines as the former type but is a little smaller, though producing slightly more power. Atwater Kent ignition has been substituted for the magneto and the use of a Stewart vacuum feed allows the carburetor to be placed higher



Cross section of the Franklin engine

Franklin Engine.

Six cylinder, 3¼x4 inches. Piston displacement 199 cubic inches. H. P. as per S. A. E. is 25.3, at maximum 31. About 1700 r. p. m. is maximum speed. The gear ratio of car on high gear is 3.9 to 1, wheel being 32 inches, which means 1,950 revolutions of engine per mile. Weight of car under 2300 lbs. Maximum speed of car 50 m. p. h. or over.

Overhead valve mechanism is used. Atwater Kent ignition. Carburetor of Franklin design.

Pistons—See that the normal working temperature in the Franklin engine is distinctly high, the makers were not very ready to believe in the aluminum piston, but they have now adopted it as stock practice and consider that the better mean effective pressure of the new engine is largely due to the improved piston cooling obtained. **At first there was a little trouble from wear on the skirt; it was difficult to get a close enough fit to insure absence of slap without abrasion. The trouble was overcome completely by turning a shallow,** square groove of screw thread form **from the bottom of the skirt to just beneath the lower ring. This holds oil securely and allows a smaller clearance than is possible with a plain piston.**

There is an interesting lubrication system employed, individual oil supply being sent to every point. The oil pump, **which is a conventional gear pattern, is mounted on a large plate, and the delivery from the pump** is distributed to a number of oil leads **by means of passages in the plate. Actually the plate is die-cast aluminum with distributing** grooves, and these grooves are made **into** closed passages by putting a piece of **thin** sheet copper over the face. **This gives direct pressure feed to all bearings on the crankshaft and to various other points.**

Valve Clearance.

Is .010 cold and adjustment is **made between end of walking beam and adjusting screw. (see page 362 for Franklin electric system and page 189 for air cooling principle. See also page 544 for "specifications.")**

The Holmes Automobile Co., Canton, Ohio, manufacture an air cooled car with many distinctive features.

*See Insert No. 3 for other motorcycle engines—also pages 843 to 846 and 811.

''Mixing Valve''—also called ''Generator Valve.''

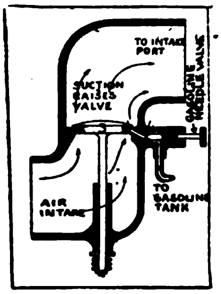


Fig. 1. Mixing valve.

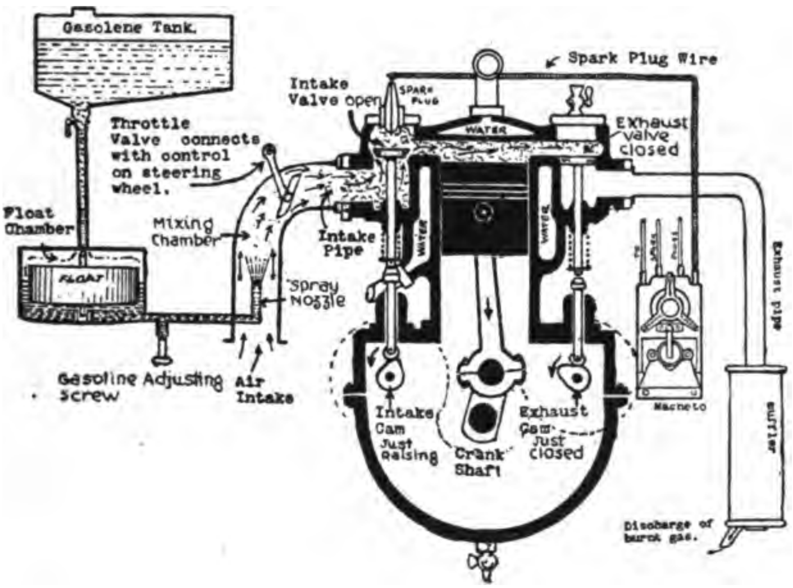
In the early days the method of mixing the gasoline and air in prop proportions was by means of a ''mixing valve,'' figure 1. The ai was drawn in at ''air intake,'' through valve (3), being opened by suction of piston forming a vacuum in crank case when going up (on a ''two cycle'' engine), or when inlet valve was open and piston traveling down on a ''four cycle'' engine.

When air is drawn in, if gasoline needle valve was open, gasoline would also be drawn in, mixed with the air and pass into cylinder in a partial vaporized condition.

The mixing valve, also called a ''generator valve,'' is still used to a small extent on two port two cycle engines. It takes the place of a check valve, as the valve (3) serves the same purpose.

Note absence of float arrangement. The gasoline is fed by gravity and when engine stops the gasoline needle valve must be cut off, otherwise there will be dripping.

Elementary Principle of the Float Feed (constant-level) Type Carburetor.



The gasoline flows from the gasoline tank to the float chamber of the carburetor through a small brass or copper pipe.

The float chamber immediately fills up until the float (made of cork or hollow copper or brass) **rises** and cuts off the flow.

The level of the gasoline in the float chamber is slightly lower than the end of the spray nozzle which extends into the mixing chamber, (otherwise gasoline would continue to run out of the spray nozzle or jet when engine is idle). This mixing chamber is connected to the inlet pipe of the engine.

If the throttle valve is opened and engine cranked, the piston will draw in the gasoline, mixed with air, through the inlet valve, (note cam is just starting to raise the inlet valve on the suction or intake stroke).

After the piston makes a complete suction stroke down and gas is drawn into the cylinder the inlet valve closes (usually after bottom, about 36°), and on the next upward stroke of the piston as the gas cannot get out of the cylinder it is **compressed**, then **ignited** by an electric spark at the gap of the spark plug. When the compressed gas is ignited by the spark, the explosive force of the gas forces the piston down. The force depending upon the amount and the amount depending upon the opening of the throttle.

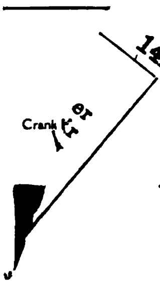
As the piston approaches the bottom of this explosion or power stroke, the exhaust valve begins to open and as the piston starts up again, the burnt gases are forced out. This is called the **exhaust** stroke. (In actual practice the exhaust valve opens about 46° before it reaches bottom, see page 100.)

The same operation is repeated over and over. The momentum of the fly wheel keeps the engine in motion until the next ''power stroke.''

The speed of an engine is varied by opening and closing the throttle valve.

CHART NO. 71—Explaining how the Gasoline is Mixed with Air and Drawn into the Cylinder of a Four Cycle Gasoline Engine—this is called Carburetion. The device which feeds the gasoline and air to the engine is called a **Carburetor.**

Chart 70 on page 138.



INSTRUCTION No. 12.

CARBURETION: Principle, Construction, Operation, Carburetor Parts. Types of Carburetors. Throttle. Speed Control. Heating or Vaporizing. Gasoline Feed Systems.

Carburetion Principle.

Meaning of carburetion: The mixing together of gasoline vapor and air is called "carburetion," and the device that keeps the two in proportion is called a "carburetor."

To get energy out of the gasoline it is necessary for it to be converted into a vapor and then mixed with a volume of air before it can be exploded in the cylinder.

There are two ways of producing this vapor, one being to expose a considerable surface of this liquid to the air, which is also caused to bubble through it and thus become impregnated with the gasoline vapor. This was the original method and was called the "**surface**" type of carburetion.

The second method is to "**spray**" the liquid gasoline through a fine spray nozzle or jet into the mixing or vaporizing tube and into which air can be drawn to intermingle with the vapor.

The device in which this operation is performed is termed a "**carburetor,**" and the operation itself is known as "**carburetion,**" from the fact that the gasoline largely consists of carbon. The mixture might also be termed "carbureted" air.

Amount of gasoline and air: It has been found that the best explosive mixture with the gasoline commonly used, is a proportion of *14 parts air to 1 part gasoline, this when maximum power is desired and ranging to 17 to 1, the latter for maximum economy. (Proportioned by weight of atmospheric pressure.)

Pure gasoline vapor will not burn; it must be mixed with air before it can be used in an engine. To burn with the greatest rapidity and heat, the air must be in correct proportion to the vapor. The exact amount of air to be mixed with a certain amount of vapor depends on the quality of the gasoline, and other conditions. The carburetor, by which the proportions of the mixture are maintained, is so made that a current of air passes through it when the piston makes a suction stroke. See chart 71—"air intake."

The air goes through this passage, in which is a small pipe called a "spray nozzle" that sprays the gasoline, so that it comes in contact with the air (see spray nozzle, page 141). The gasoline being volatile, is taken up by the air, and the mixture goes to the cylinder.

The amount of air that may flow through the carburetor, and the quantity of gasoline that may flow out of the small pipe, are adjustable, so that for a certain amount of gasoline the proper proportion of air may be admitted.

When the mixture is not correct; that is, when there is too much or too little air for the gasoline flowing out of the small pipe, the running of the engine is affected, and it will not deliver its full power.

When there is too much air for the gasoline, the mixture is said to be too **poor or lean**; when there is too little air, the mixture is said to be too **rich.**

The carburetor is connected to the inlet pipe, and no air or gas can enter the cylinder through the inlet valve without first passing through the carburetor.

---

*For Carburetor Trouble and Remedies, see index for "Digest of Troubles," and next instruction.

*That is, 14 to 1 or rich mixture is best for quick acceleration, or 15 to 1 or leaner mixture best for pulling with wide open throttle, and 17 to 1, or still leaner mixture, for high speed work (figures only approximate).

The air drawn through the carburetor on the suction stroke enters it through the "air intake" (see illustration, page 141), and passes around the spray nozzle, drawing gasoline with it; the level of the gasoline in the float chamber then drops, and the float drops also and permits more gasoline to enter the float chamber.

It is in the "mixing tube," or "mixing chamber," as it is sometimes called, that the air is brought into contact with the gasoline. The "spray nozzle," projects into the mixing tube, so that it is in the center of the current of air.

How the gasoline is drawn into cylinder with the air: When the air is not passing through the mixing tube, the liquid gasoline stands just below the open end of the spray nozzle, but as soon as the current of air passes through, it sucks the gasoline out. The current of air sucks up the gasoline, on the order of a child trying to draw the last few drops of soda through a straw, drawing in really more air than soda.

The piston of the engine, on its suction stroke produces the suction effect similar to a squirt gun drawing in water.

The inlet valve must be open to permit the gas to be drawn into the cylinder—which it is, if piston is on the suction or intake stroke, but no other stroke.

***The adjusting screw or "gasoline needle valve" regulates the amount of gasoline to be admited into the mixing tube** through the spray nozzle or jet. The regulation of this needle valve is very important, and after once being properly adjusted, a very slight turn one way or the other will affect the running of the engine.

The throttle valve, usually placed in the mixing tube, above the spray nozzle, governs the amount of gas which enters the cylinder on the suction stroke.

The throttle valve lever on carburetor, connects with the throttle lever on the steering wheel. Moving the throttle lever on the steering wheel, in a certain direction opens the throttle valve on carburetor, which increases the speed of the engine.

The more gas admitted by the throttle lever through the throttle valve, the more gas will enter the cylinder; hence more power or greater force on the power stroke, thereby giving more speed to piston of engine.

Moving the lever in the opposite direction closes the throttle valve on carburetor, reducing the amount of gas which enters the cylinder, thereby reducing the speed of the engine.

The float, in the carburetor is provided merely to prevent the gasoline overflowing and running out of the spray nozzle, when engine is not running. The float is adjusted so the level of gasoline will not quite reach the top of the spray nozzle or jet.

The floats are usually made of cork or hollow metal balls, which float in the gasoline inside of the mixing chamber. A needle point arrangement is connected with the float, which cuts off the gasoline flow when the engine stops.

The reason why engines must first be cranked, before starting, is due to the fact that a charge of gas must be drawn into the cylinder, then compressed. Compressed gas is ignited by the electric spark; this produces the power stroke, and the power from this combustion of compressed gas, together with the momentum of the fly wheel will keep the engine in motion until the next power stroke. The cycle operation of suction, compression, power and exhaust is repeated over and over again. (See page 58 for explanation of the four cycle principle.)

*This adjusting screw has been discarded on some makes of carburetors.

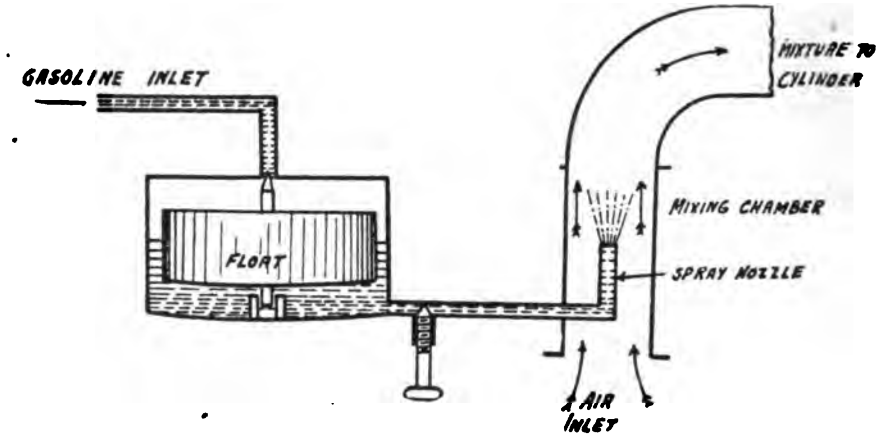


Fig. 1—The principle of a simple float feed carburetor. Note that the gasoline flows from tank through the "gasoline inlet pipe" to chamber of carburetor in which there is a float.

The purpose of the float is to cut the flow of gasoline off when the chamber is full, otherwise the gasoline would overflow at the "spray nozzle."

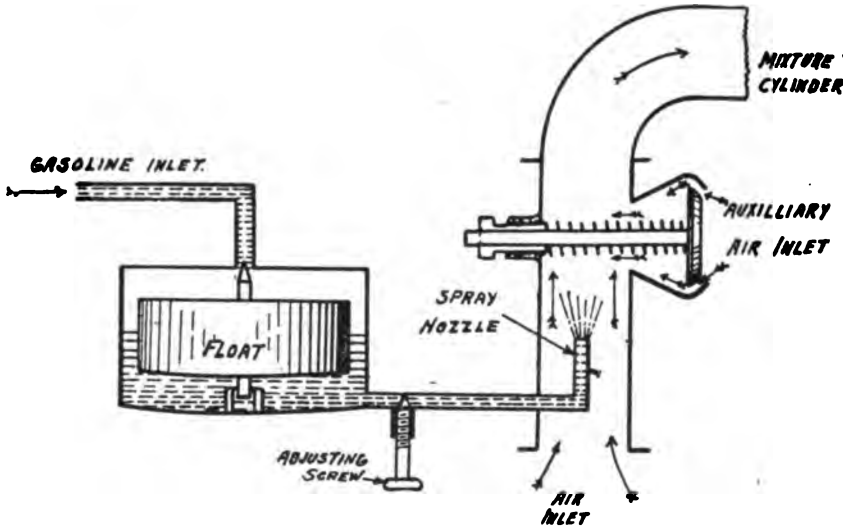
When the float is properly set (usually determined by its weight, or adjustment of float needle valve), the gasoline will not overflow at the nozzle.

When the engine is running the suction of the piston draws the gasoline through the mixing chamber from the spray nozzle, through the intake pipe from carburetor, through the intake valve on engine.

As the gasoline is consumed in the engine, the level of the gasoline in the float chamber drops and thereby causes the float to drop and more gasoline enters the chamber.

There are different methods used on various makes of carburetors for operating the float and cutting off the gasoline, but the principle of practically all carburetors is about the same.

In fig. 1 the main air supply is drawn in at the bottom of the "mixing chamber" but inasmuch as the best power of an engine is obtained by getting exact proportions of air and gasoline, the reader will note that if the speed of the engine varies the air proportion will be too great or not enough, therefore an auxiliary air intake which is automatic in action, is provided on most carburetors.



In fig. 2, note that an "auxiliary air inlet" is placed in the intake pipe above the gasoline outlet; this valve is automatic; if the engine is running at high speed the auxiliary air inlet will open in proportion to the speed of the engine, the suction being greater or less according to the speed of the engine.

Another feature of carburetion is to break the gasoline up into as many fine particles as possible so that the air will more readily mix with the gasoline and form a vapor. There are different methods of doing this which will be shown further on.

There are many different methods of arrangement of the float and air valves, but the fundamental principle remains the same.

HART NO. 72—A Simple Form of Carburetor.

ig. 1.—**Maybach** conceived the idea of using a float to keep the gasoline in spray nozzle **at a con**tant level and to draw air around spray nozzle.

ig. 2.—Krebs, later, added the auxiliary air valve.

Parts of a Carburetor.

There are various types of carburetors, in fact a score or more; although the construction varies, the principal parts are for the same purpose.

Classified according to structure and operation, we will mention the construction of the parts now in general use.

Floats.

Floats are usually made of light brass or copper in various hollow forms; the joints, if any, being carefully soldered or brazed so that gasoline cannot enter the float itself. Floats are also made of cork, well shellaced so that they will not absorb gasoline and lose their buoyancy.

The sole duty of the float is to maintain a predetermined level of the gasoline in the carburetor. This level is generally a small fraction of an inch below the jet or nozzle opening.

As gasoline flows from the main supply tank through the gasoline pipe or line into the float chamber of the carburetor, the float rises and the needle valve shuts off the further entrance of the fluid into the carburetor.

When the engine is running and using gasoline the float in the carburetor is continually falling and rising slightly, always maintaining the approximate gasoline level in the float chamber.

There are many types of floats and float mechanisms as will be seen in the illustrations of various carburetors in this instruction. By referring to chart 74 the reader will observe several float and float valve arrangements.*

Gasoline leaking into the float would increase its weight, thereby changing the proper gasoline level in the spray nozzle and cause the carburetor to flood.

Float valve mechanism: To the float an attachment is provided which will stop the flow of gasoline when engine stops. This action is obtained by the rising of the float (see fig. 1, page 148), also study the simplified explanation on page 141.

The valve which cuts off the flow of gasoline is called the **float needle valve.**

Side float type of carburetor: The float feed arrangement shown in chart 72, is shown placed to the side of the mixing tube. This form of carburetor is called a **side float type.**

Another side float type is shown in fig. 3, chart 73: The float in this type of carburetor is usually a tight box made of thin brass, the joints being made so there is little danger of leakage. In order to offset the danger of changing the level of the gasoline by tilting, the float and mixing chambers are as close together as possible.

On the float arm is a small collar, in which rests the arm of a rocker, the rocker being pivoted in the center. The other arm of the rocker rests in a similar collar on the stem of the float valve.

As the float rises, it carries with it its rocker arm, the rocker turning on its pivot. This depresses the other arm of the rocker, which closes the float valve and stops the flow of the gasoline into the float chamber.

. This is a very usual arrangement of the float valve, as it permits the valve to move downward as the float is moving upward in floating on the gasoline.

The rod through the float forms the primer, or "tickler," because depressing it lifts the float valve and admits gasoline for the purpose of priming, for starting in cold weather.

In another form, the valve stem passes through the float, and is separate from it, the inlet of gasoline being at its lower end (fig. 1, chart 74), left illustration.

A pivoted arm, or sometimes two or more are so set that the ends rest in a collar on the valve stem, and the outer ends, which are heavier, rest on the top of the float. As the float rises it lifts the arms resting on it, which depress the valve stem, closing the valve. When the float falls, the weighted end of the arms fall with it, lifting the valve stem, and thus opening the float valve.

There are several other methods of connecting the float with the float valve, as shown in chart 74, page 148.

The "gasoline adjustment or needle valve" **on above carburetors** are similar to the simple form of carburetor described in chart 72—as is also the "auxiliary air inlet," but they are placed at different positions, yet giving the same results.

The concentric float type: The floats are not always placed to the side; they are quite often placed **around** the mixing tube as shown in figs. 1 and 2, chart 73. When the float is placed around the mixing tube it is called a **concentric type of float.**

---

*Dyke's working model explains a type of float mechanism used quite extensively abroad. The throttle on this type of carburetor is called the "sliding or rotary throttle valve type," see page 154.

*For adjustment of floats of various standard carburetors, see next instruction.

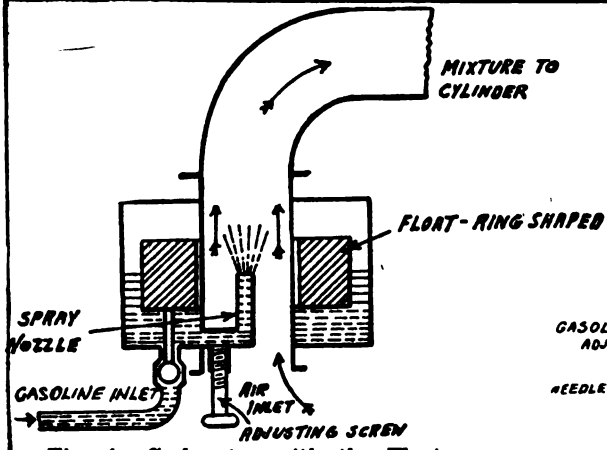


Fig. 1.—Carburetor with the Float Around the Mixing Chamber, called the concentric type of float. Air supply is drawn in at bottom of mixing chamber below the spray nozzle. This illustration shows only the main air supply.

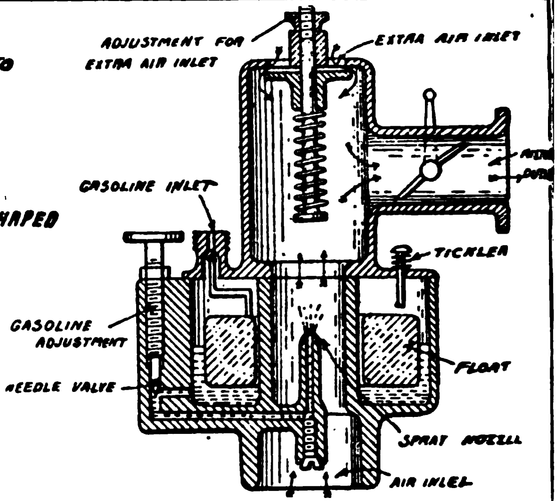


Fig. 2.—Carburetor with the Float Around the Mixing Chamber (also a concentric type). Air supply is at the bottom, below the mixing chamber and is called the "main air supply."

An Automatic Auxiliary Air Supply is shown at the top of the carburetor. This auxiliary air valve is called automatic, because the air is automatically controlled by the spring tension against the valve.

If the Engine is Running Fast the valve will open wider and admit more air, caused by a greater suction.

The Throttle Valve (Butterfly Type), is shown in the outlet tube. This outlet tube connects with the intake pipe of the engine. The opening and closing of this throttle admits more or less gas to the engine and is controlled by hand lever on the stêering wheel.

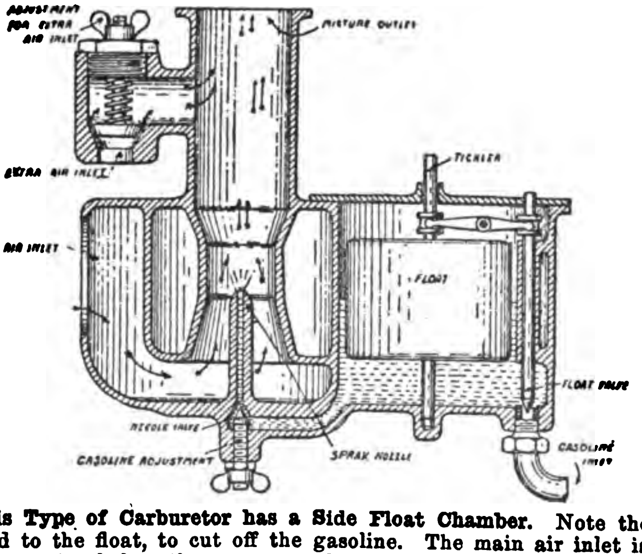


Fig. 3.—This Type of Carburetor has a Side Float Chamber. Note the float valve mechanism attached to the float, to cut off the gasoline. The main air inlet is at the side, but permits the air to enter below the spray nozzle.

The Automatic Auxiliary Air Supply is taken in at the top (over the spray nozzle to the side of mixing chamber), the same principle as the one in Fig. 2, but the arrangment only is different.

CHART NO. 73—Explaining the side Float Type of Carburetor and the Concentric Type of Float Arrangement. Also showing a different arrangement of the Auxiliary Air Intake Valve, which can be placed to the side or overhead.

Concentric means (having the same center), the center of nozzle, mixing chamber and of the float being identical.

The carburetor with the float passing around the mixing tube is called a "concentric float" type because the float surrounds both the spray nozzle and mixing chamber, all having the same center. This makes a compact carburetor and maintains a constant gasoline level in the spray nozzle regardless of the angle at which the car may be.

The float valve mechanism closing the gasoline inlet is attached to the "float." On almost all concentric float carburetors the float is made of cork.

The gasoline needle valve controls the flow of the gasoline to the spray nozzle, and the correct adjustment of it is necessary for the operation of the carburetor. It is also called the "gasoline adjusting screw." Don't confuse this needle valve with the "float needle valve."

In some carburetors this adjusting screw is placed at the top of the spray nozzle, on others at the bottom and on others, to the side. When placed as shown in fig. 2, page 148, it also helps to break the gasoline into "spray."

The regulation of this gasoline needle valve is very important and likewise very sensitive. After the carburetor is once adjusted by regulating the auxiliary air valve and the opening of this gasoline needle adjustment valve—the slightest turn one way or the other of this valve, will make a difference in the running of the engine.

The type of gasoline adjustment needle valve marked (e), fig. 2, chart 74, is of the **hand operated type**, being adjusted only occasionally. Other types of "gasoline adjustment needle valves" are; the **mechanically operated needle valve**, operated by movement of throttle through a cam arrangement by hand (chart 84), and the **automatic mechanically operated needle valve** operated by action of the auxiliary air valve (chart 82) called "metering pins," which will be treated farther on.

The main air inlet or supply is on all carburetors. See charts 73 and 74. Note, (a), in fig. 2, chart 74, **usually** placed so the rush of air entering will surround the jet or spray nozzle.

The auxiliary air inlet: The greatest diference in the **air type** of carburetor is in the position and action of the **auxiliary air inlet.** In the one shown (fig. 2, chart 73), there are openings in the top ("extra air inlet"), closed by a valve pressed against them by a "coil spring," whereas in fig. 2, chart 74 it is placed to the side.

The auxiliary air valve is controlled automatically by the vacuum created by engine piston which draws air through the auxiliary air intake, against a spring tension; for instance, see the **auxiliary air intake** (d) in the carburetor shown in (fig. 2, chart 74).

Another method for automatically opening and closing the auxiliary air intake is shown in fig. 1, chart 75, see the ball (N). Instead of a valve and a spring, balls are utilized instead.

The air valve spring. The weaker the spring the less vacuum it will take to draw the valve open, and it may be adjusted by means of a threaded sleeve (as in fig. 2, chart 74), or in various other ways.

The **stronger** the **spring,** the **less air,** hence **"richer" mixture.** The **weaker** the spring; **more air, "leaner" mixture.**

Float chamber is that part in which the float operates; it is sometimes placed around the spray nozzle and sometimes to the side, as previously explained.

The float level: In different makes of carburetors, the level of the gasoline in float chamber, and the gasoline in the spray nozzle varies from about one-sixteenth to one-eighth of an inch below to top of the spray nozzle, see pages 166 to 168 "adjusting floats of carburetors."

Spray nozzle: The fuel is discharged into the mixing chamber through the spray nozzle. (Also called "jet tube.")

As its name implies, it is intended to deliver the liquid in the form of a fine spray, which is: (1) vaporized more or less; (2) mixed with the entering air, and (3) carried by the suction into the engine cylinder.

The simplest form of spray nozzle is one having a single opening, as shown at (s) in fig. 2, chart 74. Some carburetors have **two spray nozzles** or jet tubes, as shown in fig. 3. Another type has what is called a **"multiple jet"** spray nozzle, as shown in fig. 4, see also upper right-hand illustration, page 179.

When a carburetor has more than one jet it is particularly adapted to a multiple of cylinders of large size and especially **six** cylinder engines.

The mixing chamber consits of an enclosure or passageway containing the nozzle. The gasoline and air is mixed within this tube in proper proportions and then drawn through the throttle into the engine.

The venturi tube around the spray nozzle in the mixing chamber, is the accepted type and is now made in almost all makes of carburetors. The principle and purpose of the venturi tube around the spray nozple is in order **to get a greater volume of air through a predetermined sized opening in quicker time.** Explanation of the venturi action is shown in figs. 2 and 3, page 152.

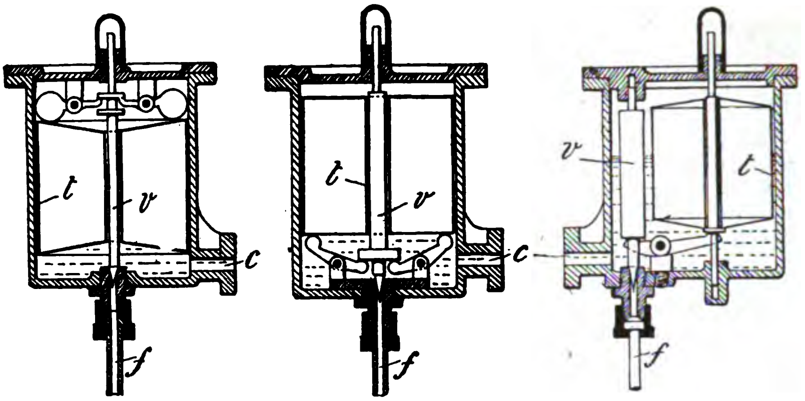


Fig. 1—The Different Mechanisms for operating the float valve on side float type of carburetors—there are several other types in use. T—is the float, usually hollow metal. V— is the float needle valve. C—is the opening leading to the spray nozzle. F—is the pipe from the gasoline tank.

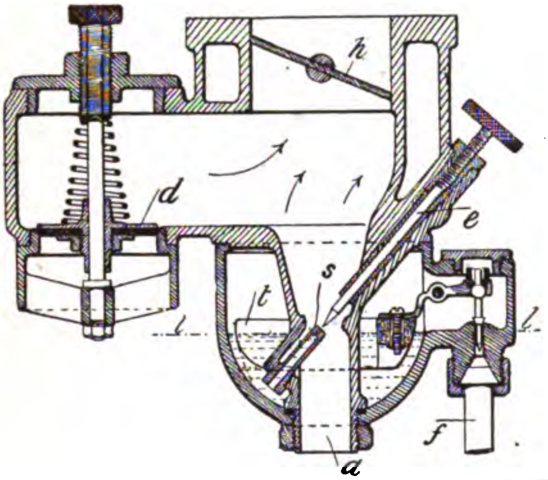


Fig. 2.—Type of carburetor with a concentric type of float. Note the float (t) (made of cork) is constructed so that it surrounds the mixing chamber and the spray nozzle.

The main air intake (a) auxiliary air intake (d) single jet spray nozzle (s) and throttle valve of the butterfly type (h) are shown in this carburetor.

The hand adjusted gasoline needle valve (e) is also shown.

A hand controlled mechanically operated gasoline needle valve is shown in chart 84.

An automatically controlled needle valve is shown in chart 82.

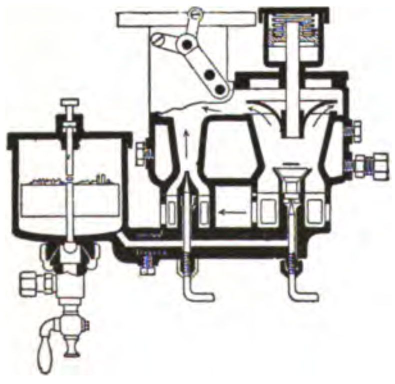


Fig. 3.—A carburetor of the side float and "double jet" type. The hand adjusted needle valves are shown at bottom of carburetor.

Carburetors are also made with three or more jets, see fig. 6, page 149.

151

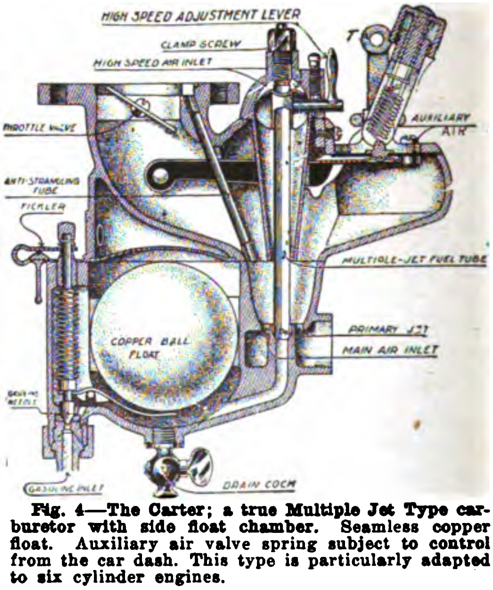


Fig. 4—The Carter; a true Multiple Jet Type carburetor with side float chamber. Seamless copper float. Auxiliary air valve spring subject to control from the car dash. This type is particularly adapted to six cylinder engines.

This illustration is of the old model—see chart 88 for improved model, upper left illustration

CHART NO. 74—Explaining Different Float Mechanisms. Gasoline Adjusting Needle. Double Jet and a Multiple Jet Carburetor.

Carburetor Principles.

Despite tremendous advancement made in internal-combustion engines during recent years, original methods of carburetion are still—broadly speaking—in practice.

The carburetor is still a comparatively primitive instrument, depending upon the suction of the piston during its descent on the inlet stroke to draw from a jet (spray nozzle) or jets—variable or otherwise—the necessary gasoline to mix with the air.

This jet can be a fixed size or it can be variable. This spray of gasoline is at the mercy of the temperature, valve timing, exhaust, inlet and combustion head design.

Carburetors as we know them at the present time, are divided into five classes:

(1) **Air valve type**—In this the fuel issues through a fixed orifice and the additional air required when the throttle is opened is admitted through an auxiliary air valve. (See fig. 2, page 144 and fig. 5, page 150).

(2) **Compensating jet type**—In this an auxiliary fuel jet comes into action as the throttle is opened. (See page 181—Zenith.)

(3) **Metering pin type**—In this the size of the gasoline orifice (jet) is increased automatically to increase the flow of fuel as the throttle is opened. (See page 151 and 178.)

(4) **Expanding type**—In this there are a number of fixed orifices which come in action one after the other as the throttle is opened. See Carter and Master, pages 179 and 180, also 151.

(5) ***The "plain tube" or "pitot" principle**:—Is a modern principle now being adopted extensively. The metering pins, dash pots, auxiliary air valves are dispensed with. The action is to supply an increased supply of gasoline or rich mixture for acceleration and then thin down to an economic mixture for normal engine speed. See page 177 for the Stromberg using this principle, and page 800 for the Schebler, as used on the Ford.

Air Valve Principle.

To properly understand the "air valve" principle we will begin with the first principles.

For a simplified explanation we will use illustration fig. 1, page 144.

The liquid gasoline enters the float chamber from the supply tank through the "float needle valve."

In the "float chamber" there is a "float," made either of cork, well shellaced to keep out moisture, or in the form of an air-tight metal box, which floats on the gasoline.

As the gasoline enters, the float rises, closing the gasoline needle valve, shutting off the gasoline when it has reached a certain depth.

The gasoline runs out of the float chamber to the spray nozzle, the float keeping the gasoline at the same level in both. When the suction of piston draws the gasoline out of the spray nozzle, the level of the gasoline in the float chamber drops, and as the float sinks, the valve is opened and more gasoline admitted.

When the spray nozzle is made with a small opening, the gasoline comes out in the form of spray, instead of as a stream, which makes it vaporize quickly.

In some carburetors, as the gasoline comes out of the spray nozzle it strikes against the end of a head projection, which breaks it into finer spray, and as the object is to make it vaporize as quickly as possible, this is an improvement.

In the simple float feed carburetor shown in fig. 1, page 144, and fig. 4, this page, it is only possible to adjust the amount of gasoline flowing to the spray nozzle. This is called the "Maybach" principle (see fig. 1, page 144).

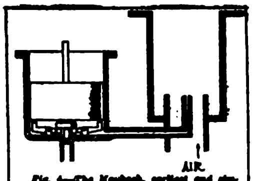


Fig. 4—The Maybach, earliest and simplest of modern carburetors

Therefore the simple form just described is satisfactory only for an engine which runs at a steady constant speed, for the speed of the air current through it does not change, and **the gasoline may be adjusted** to correspond.

The engine of an automobile, however, does not run at a steady speed; sometimes it is running fast and sometimes slow.

The speed of the air current passing through the carburetor depends on the speed of the engine; when the engine is running fast the speed of the air current through the carburetor is much greater than when the engine is running slow.

The greater the speed of the air current, the more gasoline it will suck out of the spray nozzle, and the adjustment of the gasoline flow that will give a correct mixture at a low speed will give a rich mixture when the air current moves at a higher speed. **For this reason the air supply must also be varied in order to give the proper combustible mixture.**

Auxiliary Air Valve.

To vary the air supply, different methods are used, but one used most is the auxiliary air valve, and this is where the "air-valve type" carburetor derives its name.

---

*The "Pitot tube" is an instrument for measuring pressure in moving streams of gas or liquids. Can be used facing in any direction, but as applied to the carburetor faces down stream.

The Pitot tube has been used for years for measuring fire streams, chimney drafts, etc. In the carburetor it is simply used to provide air at sufficient pressure to force the fuel from the well and be enclosed in the carburetor.

The Auxiliary Air Valve—its purpose.

Maybach conceived the idea of using a float to keep the gasoline in spray nozzle at a constant level and to draw air around the spray nozzle as per fig. 1, page 144. **Krebs,** then added the auxiliary air valve, as per fig. 2, page 144.

The auxiliary air valve was designed for engines which run at changing speeds, so that an extra supply of air was admitted when the air current flows so fast that it would result in too rich a mixture.

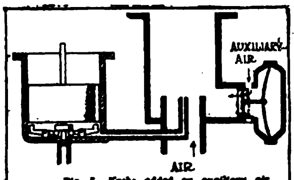


Fig. 5—Krebs added an auxiliary air valve for high speed air

The action of this auxiliary air valve depends on the greater or less suction, that faster or slower speeds of the engine gives.

In this particular type, fig. 2, page 144, and fig. 2, page 146, the extra supply of air, which reduces the rich mixture formed in the mixing chamber, is admitted through the valve placed above the spray nozzle which is controlled by an **adjustable spring.**

The suction produced from the suction stroke of the piston draws the auxiliary valve open, just as an automatic inlet valve is drawn open.

As the rush of air through the mixing chamber becomes greater and greater, because of the increased speed of the engine, the air valve is drawn open correspondingly wider, the spring being adjusted so that the proper amount of fresh air is admitted to bring the rich mixture to the proper proportions.

The float feed and the spray nozzle arrangement in both fig. 1 and fig. 2, page 144, are the same, the difference being in the auxiliary air inlet in fig. 2.

See fig. 2, chart 74 and note the auxiliary air valve as applied to the Schebler model D carburetor.

The disadvantage of this type is that owing to the relieving action of the spring valve, it does not increase the proportion in ratio, and is hardly suitable for the present day high speed flexible engine.

There are several different models now manufactured, based on the principle of the auxiliary air valve only. In these, the problem is worked out in different ways; one manufacturer uses a "**spring-controlled valve**"; another hopes to get better results by regulating the movement of the valve by "**two springs,**" instead of one; still another maker adds an "**air dashpot**" with the hope of getting finer regulation and a better functioning of the auxiliary air valve; another uses a "**dashpot filled with gasoline**"; and there are others who use metal "**balls**" to serve as the auxiliary valve; while others use what are known as "**weighted air valves,**" in which the suction lifts balls (L), as in fig. 1, chart 75, thus admitting the air which sweeps over the spray nozzle. While they all differ in the details of working out the design they are, nevertheless, based on the basic principle of the **auxiliary air valve** as originally worked out, in fig. 2, chart 72. For simplicity in nomenclature we will refer to this type as the **auxiliary air valve type.**

For air valve types of carburetors, see Kingston, fig. 1, page 152; Schebler model D, page 148.

Relation of Acceleration to Gasoline Consumption.

The rapid advance of high speed and multiple cylinder engines, have demanded "**quicker acceleration,**" meaning quicker "get away" or "pick up" of the engine.

Flexibility of control means practically the same thing or the capabilities of the engine to "pick up" from low to high speed and vice-versa. Rapid "acceleration" and "flexibility," both call for a sudden **greater amount or percentage of gasoline to air.** Quick acceleration therefore demands a surplus of gasoline for but a **brief period** after which the normal supply will care for the engine. It may be but a matter of a few seconds, yet it is of importance that this additional supply be ready and in available form for that brief period.

The Dash Pot.

To meet the sudden demand for gasoline, the added nozzle, or multiple jet has been introduced by some makers, so that when the suddenly-opened throttle brings the auxiliary air valve into use, the valve in turn brings more gasoline into the mixture, an added supply. One maker does this by a "**dashpot**" on the auxiliary valve stem, this dash pot performing a regular pump stroke and forcing gasoline into the mixing chamber by way of a separate nozzle as the auxiliary air valve opens. Once open the pumping action ceases, but the nozzle remains open for a more even demand for more fuel.

The Compensating Jet Principle.

As stated, under a heading (2) on page 149; the compensating jet type of carburetor is where an auxiliary **fuel** jet comes into action, as the throttle is opened.

Types of carburetors coming under this heading would be the Zenith, page 181; Stromberg model "H," page 177; **Marvel,** page 179.

The Metering Pin Principle.

Metering pin type.—In this, the size of the gasoline orifice or jet, is increased automatically to increase the flow of fuel as the throttle is opened. For instance, note the connection between the "**throttle**" **and the** "**needle valve**" in the spraying nozzle as shown on page 174. By a carefully computed cam action it is possible to give a **sudden lift of the needle** and thus get the desired fuel supply quickly.

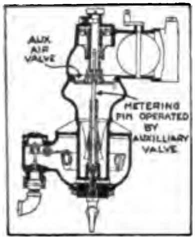


Fig. 1. The Schebler model "T" with metering pin operated by the auxiliary air valve.

The same company in another model-(T), have connected the "**auxiliary air valve**" **with the** "**needle valve**" in the nozzle (see above, and page 172), so that as the air valve opens there is a larger nozzle opening for the flow of gasoline. This principle is called the "**metering pin**" method.

Proportion of air and gas: All of these methods of providing "acceleration" are based on the accepted belief that in carburetion, **different mixtures of air and gasoline vapor are needed for different engine requirements.** The days are past when the **uniform-mixture** argument dominated, the argument that the ideal carburetor was one that would give, say, a mixture of fifteen proportions of air to one of gasoline vapor for all speeds, "acceleration," "hard pulling" with open throttle, and high-speed work with open throttle, etc., etc. The new rule is that the amount of gasoline fed into the air volume must be changed according to demands, and that if a twelve-to-one or "rich" mixture might be best for quick acceleration, that a fifteen to one, or "leaner" mixture may be best for pulling with the throttle wide open and a seventeen to-one, or still "leaner" mixture for particularly high speed work. Therefore a "**varying mixture**" must be supplied.

Example of a Carburetor with Both a Metering Pin and Dash Pot.

The Rayfield uses a "metering pin," which pin is lifted as the throttle opens in the main jet N, fig. 2, through a link arrangement, and so establishes a right to be classified as a metering pin type, but it goes further. It incorporates an auxiliary nozzle (AN) which also has a metering pin which is depressed when the auxiliary air valve opens. Thus by having two distinct nozzles it establishes its right also to be classified as an expanding type of instrument.

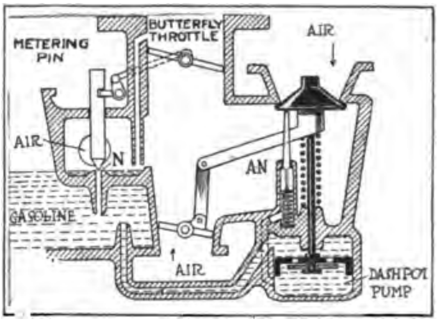


Fig. 2. The Rayfield carburetor principle with "metering pin" connected with the throttle and "dash pot," with auxiliary air intake. (see also page 175.)

But the Rayfield goes still further in that it combines a **pumping** action on the gasoline in the auxiliary nozzle AN whereby a very rich mixture is furnished for acceleration whenever the air valve is suddenly opened. This is accomplished by the piston on the lower end of the air valve stem, this piston working in a "dashpot" filled with gasoline. Gasoline enters the dashpot above the piston and is admitted to the space below the piston by the disk valve in the piston. When the air valve suddenly opens, forcing the piston downward, this disk valve is automatically closed, forcing or pumping the gasoline upward through the dotted fuel passage into the nozzle AN, where it is sprayed into the inrushing air. Only when the valve opens is this pumping function occurring and at other times the gasoline issues through this auxiliary nozzle according to the suction of the engine. **Thus the Rayfield is a compound of two metering pins in conjunction with the pumping function** for acceleration.

Other makes of carburetors using metering pins are the "Schebler" and "Stewart" see pages 172, 173, 174 and 178.

Expanding Principle. Plain Tube Principle.

In the expanding principle, there are a number of fixed orifices which come into action, one after the other, as the throttle is opened. Types of this class of carburetors are shown in fig. 6 and in the description of the "Master" carburetor on **page** 180, also on the "Carter" as described on page 179.

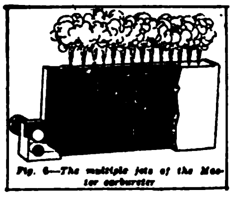


Fig. 6—The multiple jets of the Master carburetor

Plain Tube Principle

is different from this principle and other principles. It is the principle now being adopted by many carburetor manufacturers. For explanation of the "**plain-tube**" and "**pitot**" principle, see pages 149, 177 and 800.

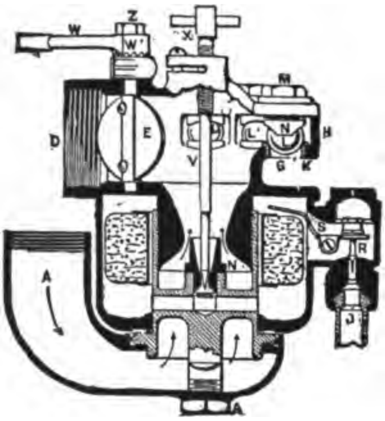


Fig. 1.—The Kingston Carburetor. Instead of using a Spring on the Auxiliary Air Intake; balls (L) Govern the Intake of Air through auxiliary air intake (G). (W) is the throttle. (E) Butterfly valve. (D) Connects to intake pipe on engine. (A) Main air intake. (V) Gasoline needle valve. The float is concentric type. Venturi mixing tube.

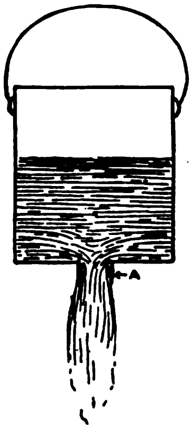


Fig. 2.

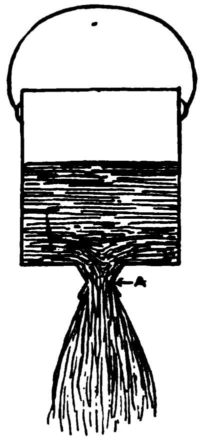


Fig. 3.

Explanation of Venturi. If two buckets are placed side by side, both filled with water, and for example a one inch opening cut in the bottom of each. One to have a plain opening as in Fig. 2-(A) and the other to have a "Venturi" opening as in Fig. 3-(A), the same volume of water would flow out of the Venturi one-inch opening in Fig. 3-(A) much quicker than through the plain one inch opening Fig. 2-(A).

Note the shape of the Venturi opening (A), Fig. 3—then note a similar shaped tube in the mixing chamber in Fig. 1 of the Kingston Carburetor where arrow points lead from N.

Note a **double venturi** on Stromberg carburetor, fig. 1, page 177. See also page 147 for explanation of "venturi."

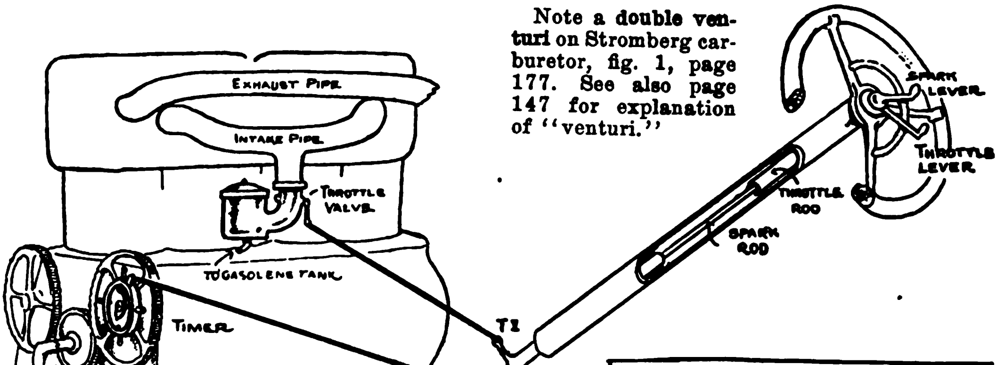


Fig. 4.—Illustrating the Connection between the Carburetor Throttle Valve on the Carburetor and the Throttle Lever on the Steering Wheel. The purpose of this drawing is to explain how the speed of an engine is controlled by hand (the usual method).

The spark must be "advanced" as the throttle is opened. This is done by shifting the timer, and causing the spark at the points of the spark plugs in the cylinder to spark and ignite the gas earlier.

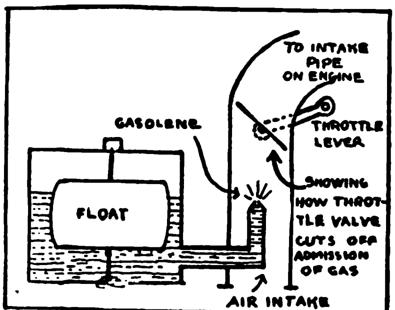


Fig. 5.—The Butterfly Type of Throttle Valve.

CHART NO. 75—Explaining the Ball Type of Auxiliary Air Intake. Explanation of Venturi. Speed Control with Throttle on Steering Wheel.

Carburetor Throttle Valves.

There are three types of throttle valves; the butterfly, rotary and sliding (see chart 76).

The butterfly throttle valve is the type of throttle used on almost all makes of carburetors. This type of throttle is shown in fig. 1, chart 76. The mechanism and method for controlling the throttle is shown in fig. 4, chart 75, also see chart 91. (T).

The throttle is placed in the mixture outlet, and the form that is shown is called a "butterfly valve." It is a disc of metal turning on pivots, so that it acts like the damper of a stove pipe. When wide open, the butterfly valve is edgeways to the flow of the mixture, but even in this position it presents resistance to the flow, which is something that should be avoided.

The "rotary" throttle valve, fig. 2, chart 76, presents no resistance whatever for there is no resistance offered. Also see "Master" carburetor, chart 89.

The sliding throttle valve is another type which presents no resistance to the flow of gas. This type is seldom used although it was formerly used quite extensively when governors were used. (See chart 76, fig. 3.)

Engine Speed; How Controlled.

The simplest and probably the acknowledged popular method for controlling the speed of an automobile engine is by **opening and closing the throttle valve on the carburetor by hand.**

A rod leading from the throttle lever on the throttle valve connects with a hand lever on the steering wheel. (See fig. 4, chart 75.) The driver then has the speed of engine under his control at all times.

If running on a level and more speed is desired, the throttle is opened by the throttle lever until the required speed is maintained. By closing the throttle, the speed is decreased.

‡Idling.

The throttle valve is never **entirely** closed; the lock screw (X) shown in (chart 82) prevents the throttle from closing entirely. Therefore engine will run slow or "idle," as it is called, when the throttle valve lever on the steering wheel is closed and car standing. To stop engine entirely; throw off the ignition switch. (see page 171).

The Accelerator.

This is the usual means for controlling the speed of the engine, see chart 76, fig. 4.

Governors.

In the early days the governor was used on a few makes of pleasure cars but discarded. The governor is now used **extensively on truck and tractor engines** as a matter of economy. See index "Governors," and page 154.

There are two types; the "throttling" type which governs the amount of gas entering cylinders and the "hit and miss" type which governs the spark by cutting it off when engine speeds up.

The former is the type in general use and the latter is used to a great extent on small stationary gas type engines. The larger stationary type engines use the "throttling" principle, fig. 5, page 154. (see index "Governors.")

*Remarks on Starting an Engine.

When an engine is started by cranking by hand, which is best done by a **quick** turn of the crank, it is necessary that a charge of vaporized, combustible gas be drawn into the cylinder, which is easy to ignite. **It is also necessary to have a good electric spark** to ignite the gas.

If we attempt to start, depending only on a magneto to supply this spark, it would be necessary to "spin" the crank in order to get the armature of the magneto up to sufficient speed to generate electricity; therefore the magneto is seldom used to start on. The usual method is to **start from coil ignition**—its source of electrical supply is derived from a battery—and after the crank shaft of the engine is in motion, then the switch is turned to the magneto, if a magneto is provided. If a **generator and battery,** then this action is automatic. Explained further on.

The modern method of starting an engine is by an electric motor, which will be explained further on.

In order to facilitate easy starting, by hand or motor, it is advisable to open throttle just before stopping engine; in order to draw in a good charge of gas—by speeding engine up with clutch out; this leaves a charge in the cylinder for starting later.

Priming to Assist Starting.

*When using the low grade gasoline, especially in cold weather, the gasoline does not vaporize freely. Gasoline vaporizes more readily when warm than when cold. The most effective temperature seems to be about 170 degrees Fahr.

Vaporizing really means evaporating, or transforming into vapor. The purpose of heating the mixture before it passes into the cylinder, is to make the gasoline more "volatile" or to evaporate quicker.

When first starting, however, heat is not provided, therefore some method of priming must be resorted to. That is, draw gasoline into the cylinder. (see page 156).

One method of priming is to prime with a "tickler," which means to depress the float by hand so that the float needle valve will open and admit gasoline to the float chamber. A wire is usually run from this "tickler" to the front of the car, where the operator can pull it and flush the carburetor before cranking (fig. 6, page 156).

Another method for priming is called the "damper" or "choke" method, and is shown in chart 78A. Instead of lowering the float, the air intake is closed. This causes an increased suction of gasoline and is called **"choking" the air supply.**

****Too much priming,** however, will fill the float chamber so full, that gasoline will run out of the spray nozzle, giving a rich mixture, on which the engine will not start, therefore it will be necessary to close switch and throttle, and crank engine a few times to draw in more air, then open switch and crank again, at which time engine ought to start if there is a good spark.

After engine is started, then some means for heating the gasoline so it will vaporize more readily should be employed.

***When an engine will not start during cold weather**—an effective method is to pour boiling water over carburetor and inlet pipe. The "**choker**" or "**damper**" principle however, usually starts engine, per page 159. **See page 489, foot note, "starting an engine by opening switch."

Too much does one of **three things—see page 205, explaining. ‡See also pages 169, 171, 652, 653.

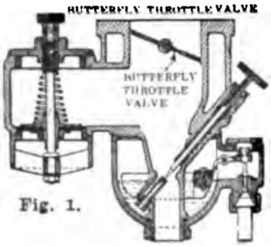


Fig. 1.

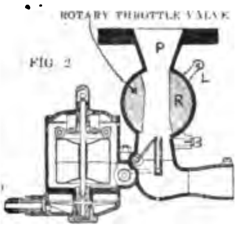


FIG. 2

Carburetor Throttle Valves.

There are three types of carburetor throttle valves: (1) the butterfly type as per fig. 1; (2) the rotary type per fig. 2, and (3rd) sliding throttle per fig. 3.

The butterfly type is in general use; it may be placed in position as shown in fig. 1, or as per fig. 1, chart 75. Usually consists of a thin disk with a throttle lever which is connected with the hand throttle lever on steering wheel.

The rotary type is different, but used for the same purpose. In the rotary type, the passage of gas from jet to intake manifold through passage (P), is controlled by a rotary cylinder (R). It is now shown full open, but by moving throttle lever (L), it can be closed or partially opened as desired. This is the principle used on the Master carburetor.

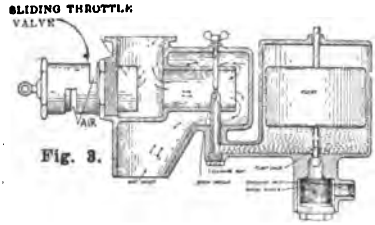


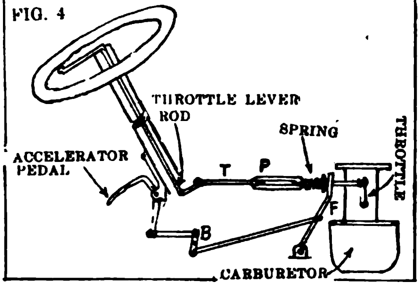
Fig. 3.

The sliding throttle valve consists of a cylinder type throttle, but instead of being rotated, it is moved in or out of its passage, which controls the amount of gas passing to the intake manifold. As it is moved out, additional air is admitted through port holes. This type was the type formerly used with a governor. It is now practically obsolete.

The Accelerator.

Fig. 4. The accelerator consists of a foot pedal which opens and closes the carburetor throttle valve independent of the hand throttle lever. By referring to the illustration, it will be noted that the accelerator will operate the throttle of carburetor without moving the hand throttle lever by an arrangement as shown. When foot accelerator pedal is depressed, the rod (F) moves against a shoulder which is fastened to the throttle shaft. The end of the shaft (T) works free in a turn buckle (P). Therefore, the throttle can be opened without disturbing the hand lever. Or the hand lever can be operated without moving the foot pedal. The accelerator is used more than the hand throttle lever. Its purpose is the same as the hand throttle lever on the steering wheel; to open and close the throttle valve. (see also page 497, 492.)

FIG. 4



The accelerator pedal is the usual means of controlling the speed of the car. When pressed downward for increase or released for decrease of speed, its action is instantaneous. When the accelerator is released, the engine immediately resumes the speed determined by the positions of the hand lever on the steering wheel. Although either the hand throttle lever or the accelerator may be used to control the speed of the car, the use of the hand lever is advised for beginners. After confidence in driving has been gained, the more delicate action of the accelerator will be preferred.

The word "accelerate" means to hasten, therefore the term is applicable here because it is quicker to operate throttling.

The Governor.

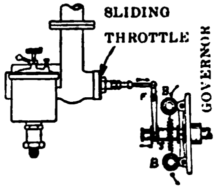
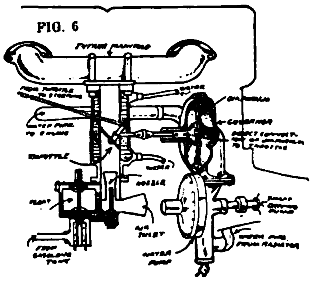


FIG 5 -The Centrifugal governor

Fig. 5. *There are no pleasure cars using the governor. Nearly all truck, tractor, marine and stationary engines use governors. One type of governor which is a "throttling" type, is the centrifugal ball type as illustrated in fig. 5, and which, no doubt the principle is familiar to all. The "sliding" throttle in carburetor is actuated by the movement of the sleeve controlled by the balls (B). The balls fly out as the speed increases causing the throttle to close.

Fig. 6. The governor formerly used on the Packard: A "hydraulic" governor of the diaphragm type is located directly above the water pump. It is operated by the pressure of the water in the water circulation system and consists of a circular chamber divided by a flexible diaphragm of leather and rubber. On one side of the diaphragm is a water space through which passes the water of the circulating system. On the other side is an air space and a plunger head against which the diaphragm presses. The plunger is directly connected with the throttle valve.

FIG. 6



If a decrease in the load on the engine causes its speed to increase, the pressure of the water, circulated by the pump, increases and, consequently, the diaphragm exerts more pressure toward the rear, tending to move the plunger and thereby close the throttle. As the engine speed decreases, the water pressure against the diaphragm is lessened and the throttle may open.

The purpose of the governor is to prevent the engine from racing when the load was removed, as by throwing out the clutch or stopping the car without shutting down the engine, also to prevent driver from obtaining over a set maximum speed.

This, however, was found unnecessary on pleasure automobiles, as high speed is a desirable feature at will of the driver, which is more easily accomplished with the movement of the hand throttle lever.

The governor, however, is a very desirable feature on truck, tractor and marine engines where the engine is supposed to run at one fixed speed, yet the load varied, as the govrnor would then keep the speed constant although the load did vary and is a saving in fuel, wear and tear.

CHART NO. 76—Types of Throttle Valves. The Accelerator. Governors. The sliding throttle and governor is seldom used. Merely shown to explain the principle.

*See index for "governor," used on truck and tractor engines.

*Vaporizing of Gasoline.

As previously stated gasoline gives off more vapor at about 170 degrees Fahr. It is the vapor mixed with air which is most desired. With the proper mixture there is more uniform power and flexibility.

Heating Methods.

There are several methods employed for vaporizing, as follows: (1) by passing hot water from the water circulation system around the water jacket of carburetor, or intake manifold; (2) by passing exhaust gases from exhaust pipe around the water jacket of carburetor instead of hot water, also around intake manifold; (3) by taking the warm air from around the exhaust pipe and passing it through the main air intake of carburetor; (4) by heating the mixture electrically before it passes into the cylinder. All of the above methods are shown in chart 78 and 78A, also see pages 160, 187.

†Heat Regulation Methods.

Carburetting means to break up the gasoline into infinitesimally small particles, mechanically, without heating, which is called "spraying." This is the best method, but very difficult to do so, owing to the different amounts of gasoline passing from spray nozzle, and on account of the variation of the throttle or the speed.

‡If a low gravity of gasoline is used, it is necesary to heat and vaporize the mixture, because it is practically impossible to break it up; but if it is a high gravity gasoline, it generates into gas quicker. In other words, it is the **vapor** that we must obtain, which is possible with high gravity gasoline. **But in using high gravity gasoline remember it will not stand as much heating as low gravity,** for if there is too much heat used, then it makes the mixture so rare that the actual amount of gasoline that goes into the cylinder is so small and at such a low flash point, it ignites quicker, and will burn and expand more like powder. It will do its work and cool before the piston gets well under way, furthermore the pressure on piston does not last as long. (see page 161.)

Owing to the low gravity gasoline now being used, the mixture is not a true vapor. Instead of forming a gaseous mixture, it condenses, inside of combustion chamber and manifold—therefore a plentiful supply of heat is required. (see pages 157, 158, 159.)

Air control: Therefore, if some method of heating the mixture is employed, as shown in chart 78A, then the heat must be **regulated,** which is usually done by a dash board or steering column air control (fig. 4, chart 78A), connected with the air intake of carburetor.

Temperature regulator: After engine is well warmed up it ought to have more air, and the more air used, less gasoline required.

If warm air was drawn into the carburetor after engine was **very hot,** then the mixture would be made too rare or lean.

We also know that gas expands in direct proportion to the degree to which it is heated. Therefore, when **heated too much,** the gas is unduly heated or prematurely expanded to such an extent that it loses a certain per cent of its energy.

The best degree for general running appears to be somewhat below the boiling point of water, i. e., between 170 degrees and 200 degrees Fahr.

Therefore some means of admitting cool air must be employed which will mix with the warm air. This would be termed a "temperature regulator," and is very simple. See page 159.

The use of low gravity gasoline requires more heating or vaporizing than a high grade. It might be compared with the firing of a furnace with soft coal.

If soft coal is properly fired and is properly mixed with air, it will produce the most **heat** without producing very much smoke. Just so with a low grade of gasoline. If properly vaporized it will work fairly well, otherwise carbon deposit and smoke will be the result. (see page 205.)

High gravity gasoline may be compared with hard coal. It is very easy to get the proper mixture of air with the high gravity gasoline, because it is so very "volatile"—meaning: there is more vapor, and less vaporizing is necessary and will "carburet" more readily; therefore it will work satisfactory in most any carburetor construction. Just so with hard coal, it will burn with less smoke and produce an equal amount of heat even though you burn it in an open shovel, and makes very much less smoke and carbon.

On stationary and high duty marine engines as low a gravity of fuel is used, as kerosene and oil, but before it can be used it must be "vaporized."

A correctly heated carburetor runs on less gasoline than an unheated one, therefore a closer adjustment of the gasoline needle valve or a smaller jet is necessary.

An engine requires more gasoline in winter than in the summer as the gasoline does not vaporize and readily mix with the air until warm.

If intake manifold is heated with water, the temperature is not so liable to cause overheating, as the temperature seldom goes above 170 to 200 degrees, especially if a thermostatic principle is used as per fig. 2, pages 130 and 187.

When intake manifold is heated by exhaust, the temperature is liable to increase to a high degree, when engine is run continuously for a long period. The latter system however, will heat the mixture **quicker** than the water system, when engine is cold. Therefore means for admitting cool air per figs. 1 and 3, page 159, and some means for cutting off the exhaust gases to manifold jacket ought to be provided, for long runs.

***More heat is required in cold weather than warm** weather.

†See also pages 157, 159, 187.

‡See page 161.

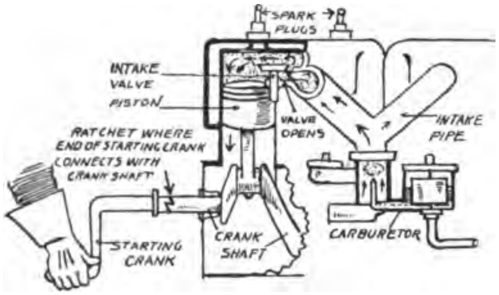


Fig. 1.—When Engine is first Started by hand or by a self-starter, the initial charge of gas must be drawn into cylinder. After it is compressed and exploded or ignited, the engine will then continue to run. Note the starting crank releases after engine is started.

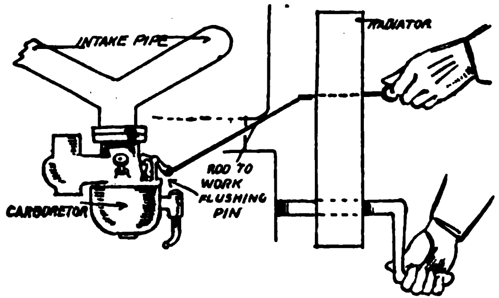


Fig. 6.—The "Tickler" Priming Method; pushing the float down admitting more gasoline.

DIFFICULT STARTING IN WINTER.

On a Cold Morning, after Engine and all parts have Become Chilled, we find that with the ordinary grade of gasoline now in use, the gasoline does not vaporise readily until it is heated; therefore, considerable cranking of the motor is sometimes necessary in order to ignite the cold, damp, unvaporized gasoline.

There are Several Methods of Overcoming this; one being to use a higher grade of gasoline, but even with the higher grade, which is difficult to obtain, on a real cold day the starting will be somewhat difficult, with some makes of carburetors.

A plan quite often used is to have a small machine oil can filled with gasoline, which is squirted into the cylinders through the pet cocks, which are usually placed in the head of the cylinder. By injecting a small quantity of gasoline into each cylinder, then closing the pet cocks, this will give the engine its initial charge, and will often start the engine without further trouble. (See Fig. 2.)

Another Method is to open the Gasoline Adjustment Needle Valve Several Turns before Cranking; this method is not advisable, however, because this adjustment valve is a very sensitive adjusted part of carburetor, and will throw the proper working of carburetor out of order after engine is heated up. If this method is employed be sure and mark a notch on the head of the valve, so that it can be turned back to its original adjusted position (Fig. 3).

Recent Improvements in carburetors to make a motor "easy starting" consist of a mechanism which connects with the main air inlet and the auxiliary air inlet of the carburetor, which closes these openings while cranking. This method causes the suction of the piston to draw into the cylinders a quantity of gasoline, which gives the same effect as if squirted in with the oil can. (See Fig. 4.)

The Usual and Common Method is to connect a wire or rod to a damper placed in the main air intake. When starting is difficult close the damper. (See Chart 79.)

In Either Method Explained, Remember that a Good Hot Spark must be provided in order to ignite this raw gasoline, because it is harder to ignite when cold than after it is warmed up.

It is also Advisable to be sure that no other trouble is the cause of the engine not starting, for instance a leak around the intake pipe, leaky float or some obstruction in the pipe.

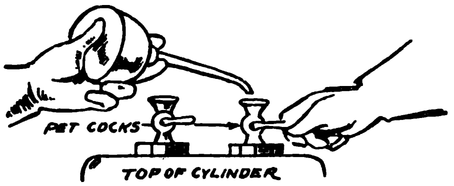


Fig. 2.—Priming by pouring gasoline in top of cylinder, through pet cocks.

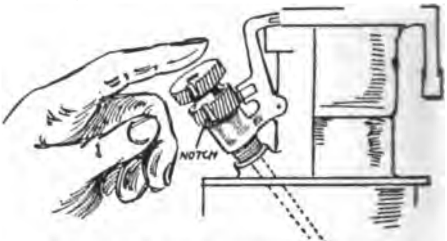


Fig. 3.—Priming carburetor, turning adjusting screw.

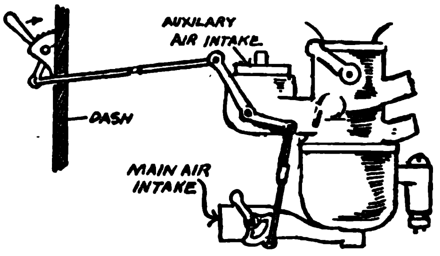


Fig. 4.—A Damper is Provided in the main air intake pipe. When closed the suction of gasoline is more than air Sometimes the tension of the spring on the auxiliary air valve is regulated from the dash or steering post. This regulates the feed of gasoline or air.

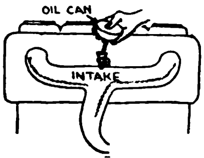


Fig. 5.—The oil can primer where gasoline is injected into manifold—simple and effective when other methods fail.

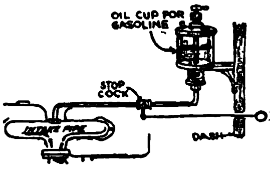


Fig. 7.—A home made primer; a ⅜" glass body oil cup of gas engine type is used.

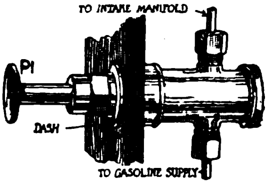


***Fig. 10.— The spray primer; a small injector** pump. The suction part of pump is connected to the gasoline supply pipe between the tank and carburetor. The other part connects to intake manifold; one stroke of plunger sprays a charge into the manifold. Imperial Brass Co., Chicago, manufacture a pump primer of this type.

CHART NO. 77—Different Priming Methods. (Also see Chart 78 for Electric Primer.)

See page 159, for "choker" **method,** which is the approved method for priming. ***A priming wrinkle which can** be used in connection here, is to have an auxiliary tank on dash under hood—about 1 pint or quart size **and fill** with high gravity gasoline and use for priming mixture.

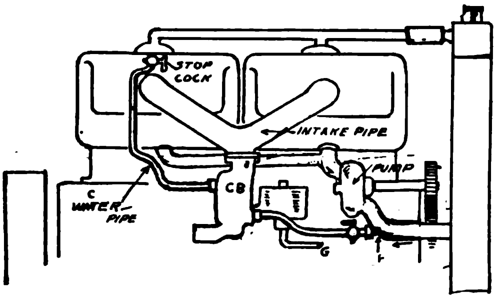


Fig. 1.—Hot water heating of carburetor: The usual method of connecting the hot water to the carburetor water jacket is to connect the upper water connection to cylinder water jacket or pipe, and lower one to suction end of pump (between radiator and pump). See that the connections are made in such a way that water will drain out of the carburetor jacket when system is drained. Place a shut off cock in the line for use in extremely hot weather.

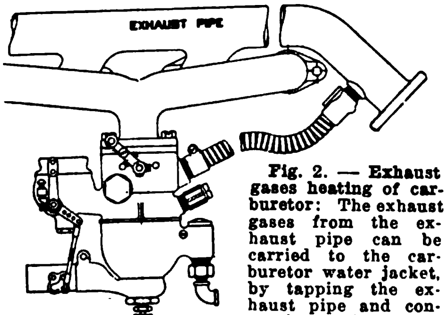


Fig. 2. — Exhaust gases heating of carburetor: The exhaust gases from the exhaust pipe can be carried to the carburetor water jacket, by tapping the exhaust pipe and connecting a flexible or copper tube to water jacket. It is advisable to use as large a pipe as possible—say ½ inch, as it has a tendency to clog up. The other opening of water jacket is left open by a copper pipe connection extending to lower part of engine for emission of gases.

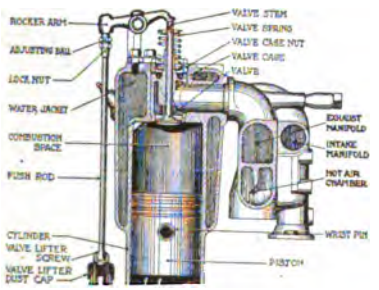
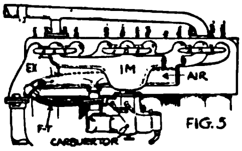


Fig. 5—Buick's exhaust heating of mixture. Note the exhaust manifold which adjoins the inlet manifold (IM). The lower part of exhaust manifold (hot air chamber) is divided from the exhaust (above). Air passes through lower chamber which is heated. Hot air is also drawn into jacket around upper part of carburetor by flexible tube connection (FT). Also see page 179, Marvel carburetor which is used on the Buick.



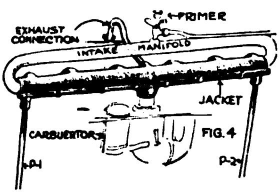


Fig. 4 — Franklin exhaust method of heating the mixture. Note jacket which encloses intake manifold through which exhaust gas passes. A cut off is provided when engine becomes very warm. P1 and P2 pipes are left open.

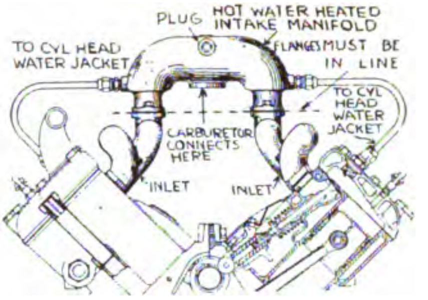


Fig. 1A—Hot water heating of mixture as employed on the Oldsmobile 8 cylinder V type engine. Note the hot water circulates through a jacket around the inlet manifold. This principle is more effective than heat around the carburetor. Exhaust heat can be passed through this jacket instead of hot water, which will heat the mixture quicker. (see also pages 82, 155 and 158.)

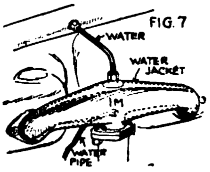


Fig. 7 — Stutz hot water heated intake manifold.

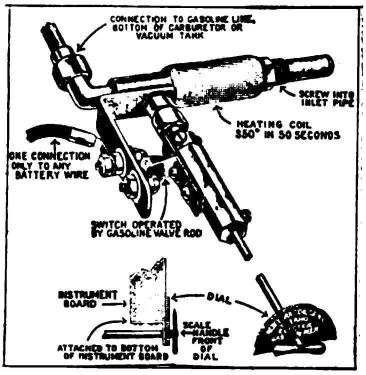

CONNECTION TO GASOLINE LINE, BOTTOM OF CARBURETOR OR VACUUM TANK
SCREW INTO INLET PIPE
HEATING COIL 350° IN 50 SECONDS
ONE CONNECTION ONLY TO ANY BATTERY WIRE
SWITCH OPERATED BY GASOLINE VALVE ROD
INSTRUMENT BOARD
DIAL
SCALE
HANDLE FRONT OF DIAL
ATTACHED TO BOTTOM OF INSTRUMENT BOARD

Fig. 8.—Electric Primer.

Fig. 8—Heating the priming mixture electrically; a pipe connects with gasoline supply. Primer is screwed into inlet manifold. Suction of piston draws in raw gasoline. An electric heating coil connected with battery heats the gasoline as it passes into manifold. (New York Coil Co., 338 Pearl St., N. Y.)

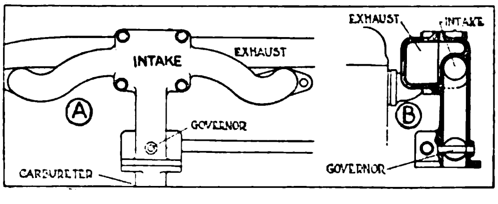


Fig. 9—"Hot-spot" heating of mixture by placing the exhaust manifold adjoining the inlet manifold, but only as part of the inlet manifold is heated; the upper part. The idea here, is to prevent condensation of fuel. The liquid particles, when they reach the top of the vertical passage, do not swing to the left or right with the gas, but go straight, since they are heavier, until they strike the hot spot.

CHART NO. 78—Methods of Heating the Carburetion Mixture.

See page 744 for a home-made heated inlet manifold, and page 735 for "air and water" injection.

Carburetion Heating Methods.

Hot water heating (see page 157) is probably the most efficient **for heating the mixture** for reasons stated on page 155. When engine is cold after standing all night the water does not heat as quickly as if exhaust gas heated, but when engine is run and warmed up and left standing, the water will remain warm for sometime and will quickly heat again. Therefore a water circulation around carburetor and inlet manifold with a temperature regulator (figs. 1 and 3, page 159) is a very good system. Water heating system can only be used with engines using a force or pump water circulating system (see insert No. 3).

Exhaust gas heating (see page 157) is the quicker method for **heating the mixture**, but overheating may occur. See page 155. The exhaust gases can be passed around the carburetor also jacket around the inlet manifold. For connecting the exhaust pipe with inlet manifold jacket a ⅝ flexible pipe with at least a ⅝" opening should be used. For an outlet a copper pipe with ½ or ⅜" opening should be connected and carried to bottom of engine to emit the gas.

Warm air may be drawn into the main air supply by means of a flexible pipe connection and hot air drum or stove as per page 159, in order to **heat the air as it is** drawn into carburetor. It is advisable **that** a temperature regulator be provided so cooler air can also be drawn in after engine is warmed up.

Priming by "choking" the air supply, is the method now used to a great extent for starting, which usually consists of a valve in the warm air supply which can be entirely closed thereby causing an increased suction of gasoline. After engine is started the choke or valve is gradually opened as engine is warmed up, at which time as much air as possible to prevent missing, is provided. Priming should be done sparingly. (see page 205).

Carburetor Attachments.

The inlet manifold is attached to the cylinder as explained on pages 159, 160, 164.

The carburetor can be placed **vertically** or **horizontally**, per figs. 4, 5, page 160.

On eight and twelve "V" cylinder engines, a duplex type of carburetor is used and is placed between the cylinders to one inlet manifold. See fig. 1A, page 157.

Air control devices and hot air attachments, see pages 159 and 157.

How To Determine Size Carburetor To Use.

The size of the carburetor should be determined by the area of the valve opening on the engine and not by the cylinder displacement, as the former is a true measure of the engine capacity. A carburetor cannot deliver more charge to a cylinder than the area of the valve opening will allow to pass.

A large carburetor with too much passage area cannot cause an engine to deliver more power than it would with one having a passage equal in area to that of the valve opening. Too large a carburetor would not only waste fuel, but reduce the power of the engine by furnishing a weak mixture.

If the carburetor is too small the engine will not develop its rated power, as it could not deliver a full charge at high speed.

When a carburetor is small for the engine, it **becomes very cold** while in operation as the amount of heat necessary to effect the vaporization of the **gasoline is more** than is available from the entering air or than could be secured through the metal carburetor by conduction. The temperature of the metal part of carburetor becomes so low that water condenses on it, and, in some cases, is in the **form of frost. These** results are produced by the use of a carburetor too small for the engine. To meet these conditions, some makers provide **means** for heating the air supply, as previously treated.

It follows that the carburetor of proper size should have its passage area equal to the valve opening of the engine. In multiple cylinder engines this area is equal to the valve opening multiplied by the number of suction strokes which takes place simultaneously, determined from the sequence of cranks, also see chart 81.

It will spell failure to fit a carburetor with a large jet and opening, to an engine in which the exhaust closes very early, because, the surplus gas cannot be expelled as completely, as with an engine having a very late closing exhaust valve.

Gasoline.

The usual fuel for automobile engines is gasoline. Gasoline is distilled from mineral oil (petroleum).

When petroleum is heated, it gives off gases just as water, when heated, gives off steam. When these gases are cooled, they become liquids, and are called gasoline, kerosene, benzine, naptha, etc.

The chief difference between them is their "volatility." When a liquid turns to vapor, or gas, it is said to be **"volatile."**

Temperature makes a great difference in the volatility of liquids; for instance, thick, heavy oil is not volatile at the ordinary temperature of the atmosphere, but is volatile when heated.

Gasoline is very volatile at the ordinary temperature of the atmosphere. It is so volatile that it must be kept in air-tight tanks, for it would entirely evaporate if left exposed to the air. Because of this volatility, gasoline must be handled with care to prevent fires and explosions. It should never be handled near an open flame.

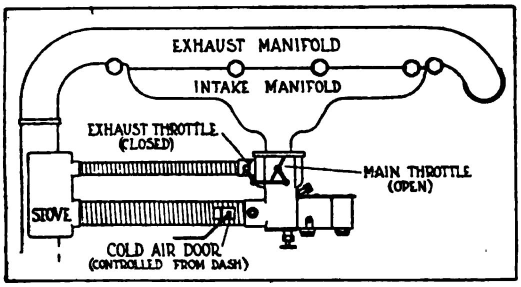
***Results of using low gravity gasoline:** A low grade of gasoline will produce poor results in any carburetor. Difficulty in starting is the main disadvantage in its use as it is not as volatile as a high gravity.

Inferior, or too much gasoline is generally indicated by a **black smoky exhaust** and **disagreeable** odor.

When a low gravity of gasoline is used some method for vaporizing must be employed, as explained on page 155.

---

*See page 205. See page 160 and index, on use of kerosene.


EXHAUST MANIFOLD
INTAKE MANIFOLD
EXHAUST THROTTLE (CLOSED)
MAIN THROTTLE (OPEN)
STOVE
COLD AIR DOOR (CONTROLLED FROM DASH)

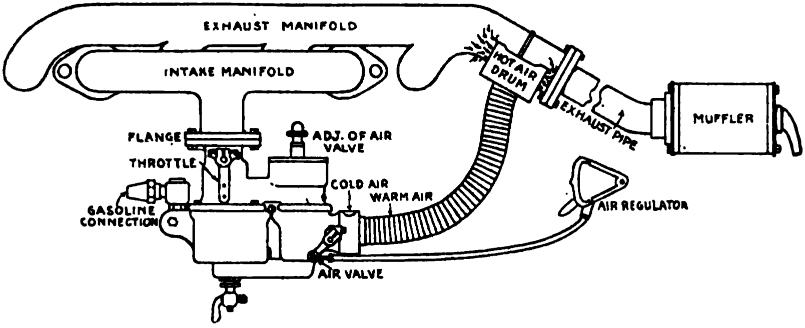
An Ideal Heating System.

Fig. 10.—Combination of heating the mixture and heating the air; exhaust manifold adjoins the inlet manifold which **heats the mixture as it** enters cylinders. Warm air is drawn around upper part of carburetor, admission of which is controlled by throttle which keeps upper part of carburetor warm. Warm air is drawn in main air supply which **heats the air.** A temperature regulator controlled from dash, admits **cool air** into main air supply when engine is thoroughly warmed up.

For starting, the lower air opening of carburetor can be closed entirely which "chokes" the air and causes gasoline to be drawn into cylinder until engine starts. This system is used **on** the Nash trucks and is **an ideal system.**

Air Heating Methods.

In chart 78 methods of heating the mixture as it passed into combustion chamber of cylinder was **treated.** We will now take up **methods of heating the air.** Also for "choking" the air entrance, to supply **a priming mixture for starting.**



Hot Air Device.

Fig. 1—Illustrates a modern principle of heating the air as it is drawn into the main air supply opening of carburetor. A **hot air drum,** also called a "stove," is **fitted** around the exhaust pipe. Not close but placed so that air can be drawn in where arrows indicate. A flexible tube then permits the air to flow to air opening of carburetor.

Fig. 1.—Showing how warm air is drawn into carburetor. Also how "choker" or air valve cuts off the air supply causing gasoline to be drawn into cylinder.

A valve is provided, called the "**air valve,**" also called a "**damper**" or "choker," which can be opened or closed by the "**air regulator**" lever, usually placed on the steering column or dash. This lever operates a butterfly type of valve in the air opening of carburetor.

Choking Air Supply to Start Engine.

When starting engine, this air valve is closed which cuts off the air supply to carburetor and causes an increased suction of gasoline to enter cylinder (or an extremely rich mixture). This gives the initial priming for starting. Immediately engine is started, the air valve is slightly opened to admit air. As engine becomes warmed up the air valve is opened more and more until full open, or where engine runs without missing or jerking which is common during cold weather. It is well known that engines will miss when first starting, due to the gasoline particles being unevaporated, due to lack of heat, but after engine is warm the gasoline becomes vaporized and the engine runs without missing. *The idea is to run on as much air as possible at all times, therefore open the air valve to the point where missing will not occur.

With this principle warm air will be drawn into carburetor at all times the air valve is open, but after engine is thoroughly warm and especially in summer, cool air can be drawn in—at opening "cold air." This can be closed entirely in the winter or regulated by hand according to the weather.

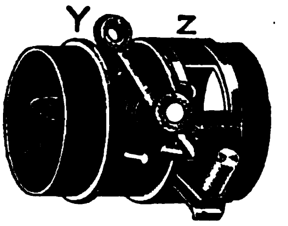


Fig. 2. — A temperature regulator or "air valve" **used on the Zenith carburetor.**

Temperature Regulator.

Fig. 2.—Temperature regulator as used on the Zenith carburetor is shown in this illustration. It is placed on the air opening of carburetor. The air control lever or air regulator operates the "air lever" or "**choke**" valve (Y), admitting more or less warm air.

The temperature of this warm air entering carburetor can be regulated by a band (Z) placed around the opening. The opening permits cool air to be drawn in and the use of this opening is governed more or less by the temperature. In summer, the opening (Z) is usually wide open, but closed more or less during cold weather.

Another type of temperature regulator is shown in fig. 3—it is the type used on the Holley carburetor. The principle is similar except, this opening (Z) is controlled from the dash.

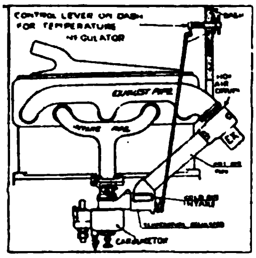


Fig. 3.—Temperature regulator used on the Holley carburetor.

Inlet and Exhaust Manifolds.

This subject is treated on pages 82 and 164, but a few words of explanation will be given here.

The inlet manifold is connected to the port openings of the **inlet** valves. On a four cylinder engine it is only necessary to have **two** openings to the manifold as there are two inlet ports together (see fig. G, page 64 and fig. 1 above). The carburetor is then connected to the flange as shown above with cap screws.

The exhaust manifold is connected in the same manner. **Usually** screw studs project from the cylinder and a clamp holds both the **inlet** and exhaust manifold in place.

For an engine to run slow and pull hard it is necessary that **packing** joint between carburetor and inlet manifold and inlet manifold and engine port openings be absolutely tight, to prevent air leaks. See pages 164 and 171.

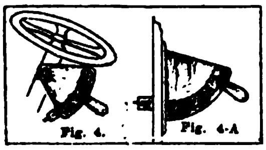


Fig. 4A. — Dash type air control.

Fig. 4. — Steering column air control.

CHART NO. 78-A—Methods of Heating the Air Entering Carburetor. Starting by "Choking" th Air Entrance.

---

*See page 735 for a device for admitting water or steam and air into mixture in intake manifold.

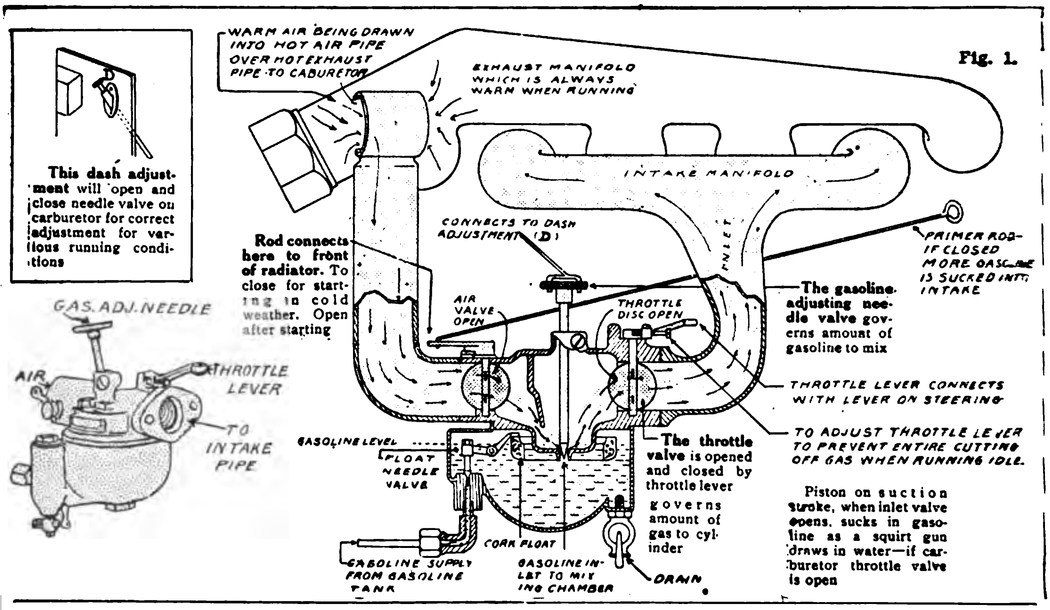


Fig. 1.
WARM AIR BEING DRAWN INTO HOT AIR PIPE OVER HOT EXHAUST PIPE TO CABURETOR
EXHAUST MANIFOLD WHICH IS ALWAYS WARM WHEN RUNNING
INTAKE MANIFOLD
CONNECTS TO DASH ADJUSTMENT (D)
INLET
PRIMER ROD—IF CLOSED MORE GASOLINE IS SUCKED INTO INTAKE
AIR VALVE OPEN
THROTTLE DISC OPEN
THROTTLE LEVER CONNECTS WITH LEVER ON STEERING
TO ADJUST THROTTLE LEVER TO PREVENT ENTIRE CUTTING OFF GAS WHEN RUNNING IDLE.
GASOLINE LEVEL
FLOAT NEEDLE VALVE
CORK FLOAT
GASOLINE SUPPLY FROM GASOLINE TANK
GASOLINE INLET TO MIXING CHAMBER
DRAIN
GAS. ADJ. NEEDLE
AIR
THROTTLE LEVER
TO INTAKE PIPE

This dash adjustment will open and close needle valve on carburetor for correct adjustment for various running conditions

Rod connects here to front of radiator. To close for starting in cold weather. Open after starting

The gasoline adjusting needle valve governs amount of gasoline to mix

The throttle valve is opened and closed by throttle lever governs amount of gas to cylinder

Piston on suction stroke, when inlet valve opens, sucks in gasoline as a squirt gun draws in water—if carburetor throttle valve is open

Ford Carburetor.

The illustration above is that of the model "Y" Kingston carburetor used on the Ford.

Float Principle.

When gasoline and air is drawn into cylinders by suction of piston, the float automatically lowers, thereby opening the float needle valve permitting more gasoline to enter the float chamber. When engine is not running the float chamber fills up, causing the float to rise, thereby closing the float needle valve. This prevents more gasoline entering which would cause overflowing and dripping. If the float happens to become loose or lowered more than intended, it would not cause the needle to cut off the gasoline supply—hence dripping would result. (note dotted lines indicate the gasoline level.)

Priming Method.

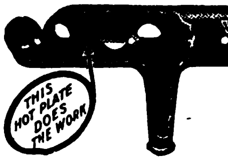
The damper or "choker" or "primer" method for priming or feeding the engine more gasoline for starting in cold weather, is operated by closing the damper or "air valve." This is used principally during cold weather. See Ford carburetor, pages 798, 802.

Heating the Air.

The air is taken in at the "air-valve" opening. A hot air pipe is shown connected which admits warm air to be drawn in from around exhaust pipe. This is a good example of **how the air is heated** before being drawn into cylinders. It will be noted that there is no auxiliary air valve on the carburetor.

Heating the Mixture.

This illustration (fig. 3) is that of the Wilmo exhaust heated intake manifold, designed for Fords and other cars. It is a good example of . method for **heating the mixture** just before it passes into cylinders.



The carburetor connects with the lower, or **inlet** part of the manifold—exhaust is upper part, **with a** plate between. By completely vaporizing the **gasoline** no residue is left to seep into crank case to thin the lubricating oil. The Whittier Co., 1st Nt'l. Bank Bldg., Chicago, Ill., mnfgrs.—who claim 40% increase in mileage on a Ford.

A Ford Kerosene Burning Carburetor.

The principle of using kerosene is similar to that of using low gravity gasoline. It should be **heated** in order to obtain vapor which will mix with air. Kerosene, being of lower gravity (thicker) than gasoline, it must be heated more. However the gasoline we are now being supplied with requires heat also and this principle will explain a very good type of **exhaust heated intake manifold, which** would also be satisfactory for present day low gravity gasoline.

The hot-pin manifold, this particular one is termed, because the pins as shown, which are inside of the inlet manifold, turn the wet gasoline or kerosene into a vapor as it strikes the hot pins.

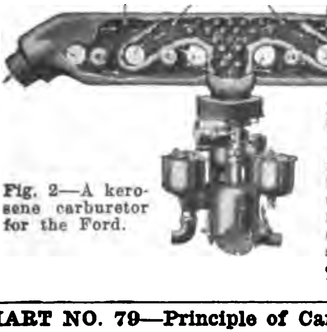


Fig. 2—A kerosene carburetor for the Ford.

The inlet manifold is cast directly into the exhaust manifold, but of course, the exhaust gases do not pass into the intake manifold, but around it which soon warms the intake manifold.

To use **kerosene** it is first necessary to use gasoline to start on. Therefore with this system there are two carburetor bowls. One on the left is for gasoline, and one on the right for kerosene. The engine is started on gasoline, from a small auxiliary gasoline tank with which it is connected. After starting on gasoline and running for a few blocks, in order to give manifold time to heat, the gasoline is cut off and the kerosene side of carburetor is turned on. An operation controlled by a special designed throttle lever. Manufacturers are Kerosene Burning Carburetor Co., 2015 Michigan Ave., Chicago, Ill.

CHART NO. 79—Principle of Carburetor Action and Hot Air System for the Ford. Wilmo Exhaust Heated Manifold. A Ford Kerosene Carburetor—see also pages 827, 754.

Another Kerosene Carburetor Mfgr. for a Ford is Kerosene Motor Co., Peoria, Ill.

—continued from page 158.

A test by hand: To ascertain how near kerosene you are getting, pour a little gasoline in the hand. When it evaporates slowly and leaves a greasy deposit, it is a very low grade. When it evaporates rapidly and leaves the hand dry and clean, it is a higher grade. This furnishes a fairly reliable test.

Testing gasoline with a hydrometer was the method used a few years ago. It was used as follows: Fill the glass tube with the gasoline, insert the hydrometer, which will float. The gravity of the gasoline is determined by the depth the hydrometer sinks in it. A scale is graduated on the upper portion of the hydrometer and the level of gasoline indicates the specific gravity. The scale usually runs from 60 to 80. Gasoline under 60 test ought not be used. It averages about 64 to 68 and the better grade 72.

Gravity is no longer an accurate test of the merits of the fluid, the only really accurate test being from a maximum and minimum boiling point. It is, of course, not practical for the average owner to make such tests and the best rule is to purchase from a reliable distributor, who handles goods manufactured by responsible distillers.

Most of the gasoline today sold for motor car use differs from that of several years ago in that it is not all of one grade, but is a compound or blend of the different petroleum elements; some of it being very light and volatile, while about one-fourth of it may have a boiling point higher than that of water, and is correspondingly difficult to convert into a vapor.

To use this fuel it is necessary that the whole carburetor and intake manifold system be thoroughly heated. Without this heat the carburetor setting will have to be changed and made richer than necessary, while the extra heavy part of the fuel, not vaporized, will burn slowly in the cylinder, forming carbon, sooting up spark plugs, etc.

There is, of course, a period of time just after starting the engine cold, when the rich mixture will be necessary (and can be furnished by the dash control), but the control should be released as soon as the engine becomes warm.

It is also advisable, while the engine is cold, to avoid opening the throttle full, as the fuel vaporizes much more readily in the suction or partial vacuum which exists in the manifold while the throttle is partly or completely closed.

In very cold weather it is advisable, instead of readjusting the carburetor or using the dash control continuously, to cover part of the radiator surface so that the normal temperature is maintained under the hood.

In some parts of the country there is so great a range in the constituents of the gasoline sold that the lighter or more volatile fractions may, in warm weather, boil in the carburetor, under normal operation of the car. In this case, the hot air supply to the carburetor may be disconnected, while care should be taken that the gasoline supply line from the tank to the carburetor does not approach the exhaust pipe, cylinder walls or other heating influence.

If the gasoline should catch fire, do not try to put it out with water, for as the gasoline will float on water, it will only spread the flames. **Damp** sand, flour or a wet blanket will smother the fire.

*Low Gravity vs. High Gravity Gasoline.

The proper gravity of gasoline to use is governed by conditions. In the summer a low gravity vaporizes much easier than in the winter; therefore the engine starts easier.

A great many claim the low gravity gives as good or better results than high grade—probably it does, as there are more †heat units per gallon, but as a matter of **easy starting** and absence from carbon deposit, the high gravity is preferable, unless the carburetor has been properly adjusted and priming and heating methods provided. (see page 155.)

With the high gravity we have a high "flame" rate (mixture burns rapidly), whereas, with the low gravity we get a higher combustion heat, but slower "flame" rate. With a high flame rate the mixture burns rapidly—pressure rises quickly and imparts a powerful push at commencement of stroke, but falls away equally quick as the stroke progresses.

With low gravity gasoline, the reverse occurs. The explosion generates slowly and does not impart a violent shock, but with a retarded flame rate, the pressure predomniates through a much greater proportion of the stroke. The results are obvious, with high speed, as racing, the high gravity is best. For medium speeds, where steam-engine like power is required, combined with fuel economy, low gravity is best—providing the carburetor has been readjusted for the low gravity fuel and proper heating arrangements provided.

Owing to the great amount of carbon in low gravity gasoline it is very necessary that the carburetor be properly adjusted.

The starting will be more difficult with low gravity, but with the use of a primer and hot air arrangement, this trouble can be overcome.

It is a well known fact that an engine, especially an old one with loose bearings and slack pistons, will run much more quietly on low gravity gasoline. The reason is due to the slow flame rate; the pressure is gradual on the piston head and presses rather than slams.

Fuel Troubles.

Water in gasoline: Is indicated generally when the engine runs irregularly and finally stops. This will often prevent starting of the engine. Water is frequently present in gasoline, and particularly when the tank is low, is liable to get into the pipes and carburetor. The drain cock at the bottom should be opened occasionally to let off the water.

In cold weather, this water is liable to freeze, preventing the action of the carburetor parts. Ice in the carburetor can be melted only by the application of hot water, (or some other non-flaming heat), to the outside of the float chamber.

Gasoline ought to be strained: Many carburetor troubles would be avoided if more care were taken to free gasoline of all dirt before its entrance into the tank. When filling the tank use a strainer funnel; chamois skin makes an excellent filter; if a wire gauze be used it should have a very fine mesh. In the absence of a strainer, funnel or chamois use three or four layers of fine linen fitted inside an ordinary funnel. Never use the same funnel for both gasoline and water. (See chart 80.)

Old gasoline: Left in carburetor for some time, when car is not in use, will lose its strength. If the engine should not start easy, then drain the float chamber.

A strainer should be on all gasoline tanks or lines as water and sediments being heavier, always settle at the bottom.

Addresses of carburetor manufacturers classified under the type carburetor they manufacture is given on page 162. For detail information catalogs are of value.

---

*It is important that the low gravity gasoline be heated, otherwise condensation takes place in cylinders, see page 205. †See pages 861, 909, meaning of B. T. U.

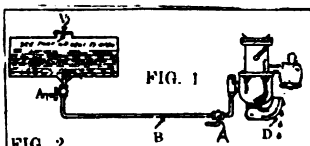


FIG. 1

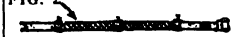


FIG. 2

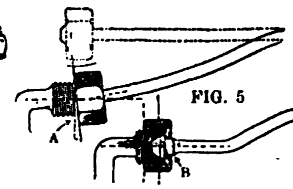


FIG. 5

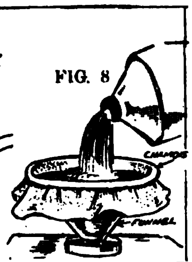


FIG. 8

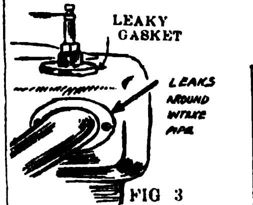


FIG 3

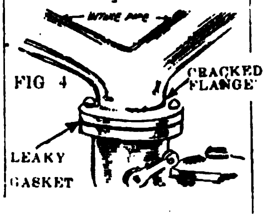


FIG 4

Gasoline Troubles.

If gasoline fails to flow; see that the small vent hole in cap (V-fig. 1) is open. See if the valve (A) on tank or on carburetor has jarred closed.

If this fails, take off pipe and blow it out.

If this fails take carburetor apart and see if clogged up with waste, string or some other substance.

The tank of a fuel system is always provided with a small hole, usually drilled through the filling cap, by which air may enter to replace the gasoline as it is drawn off.

If this hole becomes clogged with dirt the gasoline in flowing out will tend to create a vacuum, and the flow will stop.

The outlet pipe should project slightly above the bottom of the tank, so that water and dirt may settle, and not be carried to the carburetor—a filter screen should also be provided. **Gasoline drips from carburetor—see** page 166.

Leaks in tank. Minute leaks of the fuel tank are hard to locate because the gasoline evaporates so quickly and the amount is too small to detect readily with the naked eye. Where one is thought to exist it can be located by placing your finger over the leak and telling by the gasoline odor.

Gasoline feed pipe connections should use special unions as shown in fig. 5. The threads are very fine and can easily be crossed. Therefore use precaution to not "cross-thread" when joining a gasoline pipe coupling as at (A). In B the threading is straight and correct.

Gasoline rots rubber rapidly and should not be conveyed through a rubber hose, nor should joints be packed with rubber. Shellac or soap may be used when screwing joints together, as it helps to make them tight.

Draining and straining: The lowest point of the gasoline line is usually at the carburetor and should have a cock or plug so that the system may be drained. There is usually a strainer in the feed pipe, consisting of thickness of brass wire gauze through which the gasoline flows. This strainer is often built into the carburetor, and may be withdrawn for cleaning by unscrewing a plug. As the carburetor is always placed at the lowest point of the feed pipe, impurities will settle in it, and in the best form, there is a plug that may be unscrewed to permit the parts to be easily cleaned. Fine steel wires should be carried in the kit, for cleaning the fine passages.

Water vs. gasoline: To prevent water getting in the gasoline tank; strain through a chamois.

It is said that when gasoline runs through a chamois strainer in the funnel, it generates static electricity. So long as the funnel fits securely into the mouth of the tank, thus creating a "ground," the electricity does not accumulate. If the funnel is held in midair, free of the sides of the tank, no "ground" is formed. Consequently when the amount of electricity is sufficient to produce a spark, that spark jumps to the nearest "ground." Do not put gasoline through a chamois skin unless funnel is grounded. Water in gasoline in the winter will freeze and clog up the flow.

A broken gasoline pipe has been fixed temporarily when out on the road by cutting off about two inches of the gas pipe tubing and placing on each end of the broken pipe and wrapping it well with tape (per fig. 2). Don't permit the rubber tubing to remain on very long as it will last only a short while and will clog up the gasoline pipe.

Missing: If engine persists in missing and is not the fault of ignition, then **look for air leaks in the inlet manifold** (per figs. 3 & 4), examine gaskets and cracks in the intake casting—providing the trouble is not in the ignition.

Leaks in the intake pipe gasket is a very common cause for missing at low speeds, and is best detected by letting the engine run at the missing speed. Take a squirt can full of gasoline and squirt around all the intake pipe joints. If you detect any difference whatsoever in the running of the engine there is a leak.

Cracked flanges can be repaired by having welded by oxy-acetylene process. See page 164 for kind of gasket to use.

Carburetor Manufacturers' Address.

Mnfgr's of Compensating Jet Type Carburetors.

Stromberg	Stromberg Carburetor Corp., Chicago.
Sunderman	Sunderman Corp., Newburgh, N. Y.
Fletcher	L. V. Fletcher & Co., New York.
Longuemare	Longuemare Carburetor Co., New York.
Zenith	Zenith Carburetor Co., Detroit.
Marvel	Marvel Carburetor Co., Flint, Mich.
Holley	Holley Bros. Co., Detroit.
Miller	Miller Carburetor Corp., Los Angeles.
Ball & Ball	Penberthy Injector Co., Detroit.
Johnson	Johnson Co., Detroit (used by Reo).
Tillotson	Tillotson Carburetor Co., Toledo.

Juhasz Carburetor Co., 244 W. 49th St., N. Y.

Mnfgr's Metering Pin Type Carburetors.

Bayfield	Findeisen & Kropf Mfg. Co., Chicago.
Schebler	Wheeler & Schebler, Indianapolis.
Tom Thumb	National Equipment Co., Chicago.
Stewart	Detroit Lubricator Co., Detroit.
Heath	M. K. Bowman-Edson Co., New York.
Webber	Webber Mfg. Co., Boston.
H & N	H & N Carburetor Co., New York.
Newcomb	Holtzer-Cabot Co., Boston.
Shakespeare	Shakespeare Co., Kalamazoo, Mich.

Mnfgr's of Air Valve Type Carburetors.

Kingston	Byrne, Kingston & Co., Kokomo, Ind.
Zephyr	Federal Brass Works, Detroit.
Breeze	Breeze Carburetor Co., Newark, N. J.
Shain	C. D. Shain, Brooklyn, N. Y.
K-D	K-D Carburetor Co., Cleveland.
Ensign	Ensign Carburetor Co., Los Angeles.
Air Friction	Air-Friction Carburetor Co., Dayton, O.

Mnfgr's of Expanding Type Carburetors.

Master	Master Carburetor Corp., Detroit.
Carter	Carter Carburetor Co, St. Louis.

CHART NO. 80—Gasoline Feed Troubles (see chart 81-A for the modern vacuum and pump, and gravity feed systems) **Address of Carburetor Manufacturers above. See page 543 for cars using the different makes of carburetors.**

A gauge to indicate the amount of gasoline in the tank is shown on page 823.

Gasoline Feed Methods.

There are five systems: (1) gravity; (2) pressure; (3) combined gravity and pressure; (4) gravity and pumping; (5) gravity and vacuum. (see page 164.)

The Stewart Vacuum and Gravity System.

Is explained on page 165. A few pointers as to the installation and care will be given here.

Installation.

The top of vacuum tank must be above level of gasoline in main gasoline tank when full, even when car is going down steep grade.

The bottom of vacuum tank must be not less than 3 inches above carburetor, 5/16" copper pipe is used.

Do not install directly over generator or wiring terminals, on which gasoline could leak.

Never tap through a water jacket if intake manifold is provided with one. Always tap intake manifold at point as close to the intake of one of the cylinders as possible. Be careful in bending tubing. **The air vent must be placed at as high a point as possible under the hood.** Best location for tank is on engine side of dash.

On 8 or 12 cylinder, "V" **type engines with** two inlet manifolds, a "Y" connection **is made** at (D) on top of tank and both manifolds tapped.

Care and Repair of Stewart System—page 165.

Vent Tube Overflow.

The air vent allows an atmospheric condition to be maintained in the lower chamber, and also serves to prevent an overflow of gasoline in descending steep grades. If once in a long while a small amount of gasoline escapes no harm will be done, and no adjustment is needed.

However, if the vent tube regularly overflows, one of the following conditions may be cause:

(a) Air hole in main gasoline tank filler cap may be too small or may be stopped up. If the hole is too small or if there is no hole at all, the system will not work. Enlarge hole to ⅛ inch diameter, or clean it out.

(b) Vacuum tank may not be installed quite high enough above carburetor. If bottom of tank is not 3 inches above carburetor, raise the tank.

Gasoline Leakage.

If gasoline leaks from system, except from vent tube, it can only do so from one of the following causes:

(a) A leak in outer wall of tank may exist. If so, soldering up the hole will eliminate trouble.

(b) Carburetor connection in bottom of tank may be loose. If so, it should be tight.

(c) There may be leak in tubing length D or C.

Failure to Feed Gasoline to Carburetor.

This condition may be due to other causes than the vacuum system. **To test;** after flooding the carburetor, or "tickling the carburetor," as it is commonly called, if gasoline runs out of the carburetor float chamber, you may be sure that the vacuum feed is performing its work of feeding the gasoline to carburetor.

Another test is to take out the inner vacuum tank, leaving only the outer shell. If you fill this shell with gasoline and engine still refuses to run properly, then the fault clearly lies elsewhere and not with the vacuum system.

If the trouble of failure to feed is in the vacuum tank, one of the following may be the cause:

(a) The float (G), which should be air-tight, may have developed a leak; thus filling up float with gasoline and making it too heavy to rise sufficiently to close vacuum valve. This allows gasoline to be drawn into manifold, which in turn will choke down the engine.

(b) Flapper valve may be out of commission.

(c) Manifold conenctions may be loose—allowing air to be drawn into manifold.

(d) Gasoline strainer or tubing clogged up (below K, fig. 2, page 165). Look to this first.

Remedies for Above Troubles.

(a) **To repair float;** remove top of tank (to which float is attached). Dip the float into a pan of hot water, in order to find out definitely where the leak is. Bubbles will be seen at point where leak occurs. Mark this spot.

Next, punch two small holes, one in the top and the other in the bottom of the float, to permit discharge of the gasoline. Then solder up these holes and the leak. Test the float by dipping in hot water. If no bubbles are seen, the float is air-tight.

In soldering float, be careful not to use more solder than required. Any unnecessary amount of solder will make the float too heavy.

To overcome the condition of a leaky float temporarily until you can reach a garage, remove plug (W) at the top. In some cases the suction of the engine is sufficient to draw gasoline into tank even with this plug open, but not enough to continue to be drawn into manifold. If, however, you are not able to do this, close up plug (W) with engine running. This will fill tank. After running engine until tank is full remove plug (W) until gasoline gives out. Continue repeating same operations until a repair station or garage is reached, when the leaky float can be remedied.

(b) A small particle of dirt getting under the flapper valve (H), might prevent it from seating air-tight, and thereby render tank inoperative.

In order to determine whether or not the flapper valve is out of commission, first plug up air vent; then detach tubing from bottom of tank to carburetor. Start engine and apply finger to this opening. If suction is felt continuously then it is evident that there is a leak in the connection between the tank and the main gasoline supply, or else the flapper valve is being held off its seat and is letting air into the tank, instead of drawing gasoline.

In many cases this troublesome condition of the flapper valve can be remedied by merely tapping the side of the tank, thus shaking loose the particle of dirt or lint which has clogged the valve. If this does not prove effective, remove tank cover, as described below. Then lift out the inner tank. The flapper valve will be found screwed into the bottom of this inner tank.

To Fill Tank.

To fill the tank, should it ever become entirely empty; with the engine **throttle closed** and the spark off, turn the engine over a few revolutions. This takes less than ten seconds, and will create sufficient vacuum in the tank to fill it.

If the tank has been allowed to stand empty for a considerable time and it does not easily fill when the engine is turned over, this may be caused by dirt or sediment being under the flapper valve (H).

Or, perhaps, the valves are dry. Removing the plug (W) in the top and squirting a little gasoline into the tank will wash the dirt from this valve, and also wet the valves, and cause the tank to work immediately. This flapper valve sometimes gets a black carbon pitting on it, which may tend to hold it from being sucked tight on its seat. In this case the valve should be scraped with a knife.

To Clean Tank.

Remove the top of tank and take out inner shell or vacuum chamber. This will give access to lower chamber from which dust or dirt may be removed. Clean tank every three months.

To Remove Top.

After taking out screws, run the blade of a knife carefully around top, between cover and body of tank, so as to separate gasket without damaging it. Gasket is shellaced.

Auxiliary vacuum pump; on some cars (Hudson), a small hand vacuum pump is provided on dash, which if vacuum tank should become empty, it would not be necessary to turn engine over, but merely operate pump connected by check valve to pipe C, page 165, which will create sufficient vacuum to draw gasoline from main tank.

Engine primer; see foot note, page 165.

Additional pointers: suction valve (A) and atmospheric valve (B), fig. 2, page 165, can easily be ground if necessary. The spring (E) may be weak. There is a fibre washer at bottom of stem on float—this sometimes swells and causes trouble—**always look for air leaks first**—if tank will not fill.

FIG. 1

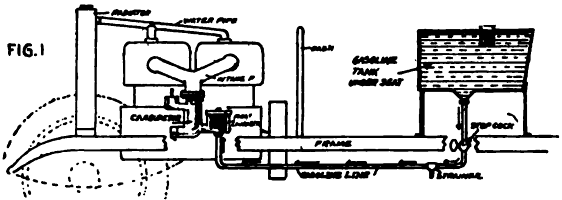


FIG. 2

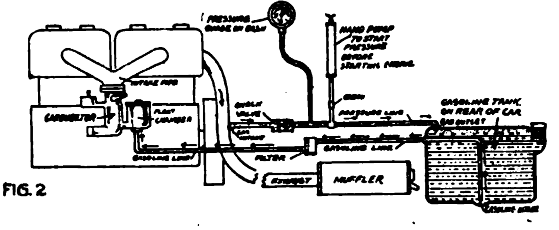
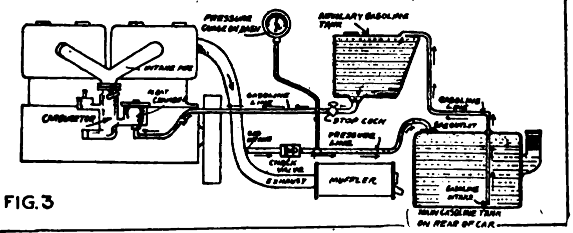


FIG. 3



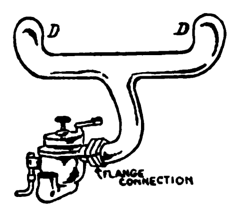


Fig. 4 —Carburetor Attached Horizontally

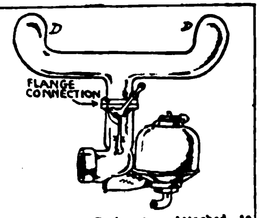
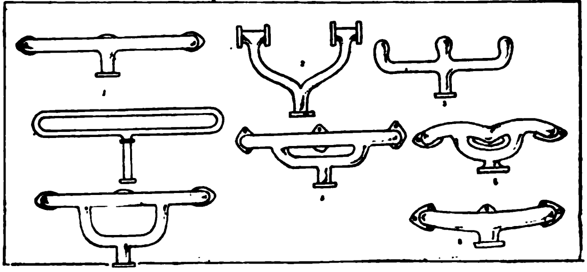


Fig. 5 —A Carburetor Attached to the Intake Manifold Vertically



Some of the methods which have been employed for six cylinder engine inlet manifolds. A modern construction is shown in lower illustration, page 82.

Gasoline Feed Systems.

Fig. 1.—Gravity feed tank is placed **above the** level of carburetor so that the **gasoline flows** from tank to carburetor by gravity. **The tank** can be placed at any point on the **car, just so** it is above the level of carburetor.

The disadvantage on large cars **where tank** is not close to carburetor; when **ascending hills**, or on the side of an incline the **gasoline may** fail to flow through pipe.

Fig. 2. Pressure Feed—With this **system the tank** is placed in the rear and is **air tight. A** hand air pump is connected to obtain **the initial** pressure in tank. After engine is **started the** exhaust gases pass through check valve **to tank**, creating a pressure, which forces **the gasoline** to carburetor.

A small pipe is used for the exhaust **passage**. The pipe being exposed to the air, **the gases are** cooled and prevent a flame. The **check valve** prevents the gas passing back, as it **can pass but** in one direction.

Disadvantage—The pressure is liable to interfere with the proper operation of the float*

Fig. 3. Combined gravity and pressure feed—gasoline is forced by exhaust pressure **from tank** to an auxiliary tank, placed above **the level of** the carburetor—the gasoline then **flows to carburetor** by gravity.

The auxiliary tank is small and is **placed close** to carburetor, so the gasoline will **always feed**

The modern gasoline feed system is explained in chart No. 81A.

Carburetor Gaskets.

When fitting a carburetor, a gasket **must be** placed between the carburetor flange **and the** flange on intake pipe.

The best form of gasket is copper, interlined with asbestos. Multibestos or similar **material** can also be used and coated on each **side with** shellac. Leather could also be used **here but** would not answer elsewhere, because **it would** get too hot. If material is used which **has a** rough edge, it is important to watch **that none** of it gets into the carburetor pipe.

At the point (D) where inlet manifold covers the inlet ports, a copper gasket must be **used** and **drawn tight** to prevent **air leakage. Be** sure there are no air leaks where **carburetor** joins the intake pipe, and where the **intake pipe** connects to the engine.

The air inlet of the carburetor, if **exposed to** dust and dirt, should be placed so **that dust** may not be drawn in.

The inlet manifold, connecting the carburetor to **the inlet valve port chamber, should present no resistance to the flow of the mixture.** Sharp bends or turns will make it harder for **the mixture** to pass.

When fitting a carburetor be sure there is no vibration, if there is, the result will **probably** be a broken flange as shown in chart **80.** If there is vibration, place a small iron **hanger** from a nut on engine frame to **carburetor, to** steady it and also to take strain off **intake pipe**

Inlet Manifolds.

Engine manufacturers endeavor to **make a** manifold which **will** have the least **number of curves,** and as straight and as short a path for **the gas to travel** through as possible.

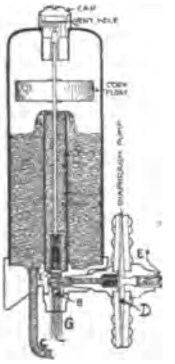
The ideal inlet manifold is easily specified. It is one in **which** no unnecessary resistance is offered to the flow of the mixture.

An inlet manifold for a six cylinder engine which will **deliver** an equal mixture to each cylinder has been a problem with **manufacturers.** If the distance is too great **the gas tends to condense.**

The inlet manifold in use today, is smaller in diameter than formerly, owing to the poor grade of gasoline. The fuel is **harder** to "break up" and will not vaporize readily—therefore it **condenses** and clings to the inner walls of manifold. By **having** smaller intake manifolds, the mixture is sucked through at **a greater** speed, which in a way prevents this condensation.

With too large an intake, using present low grade fuel, after **a hard** pull, the engine tends to "choke" and miss until it runs **a short** distance on a closed throttle.

Water jacketed manifolds are now the approved **method. See** (lower illustration), page 82. On many engines the **intake manifold** is cast right into the cylinder. (see also page 157.)



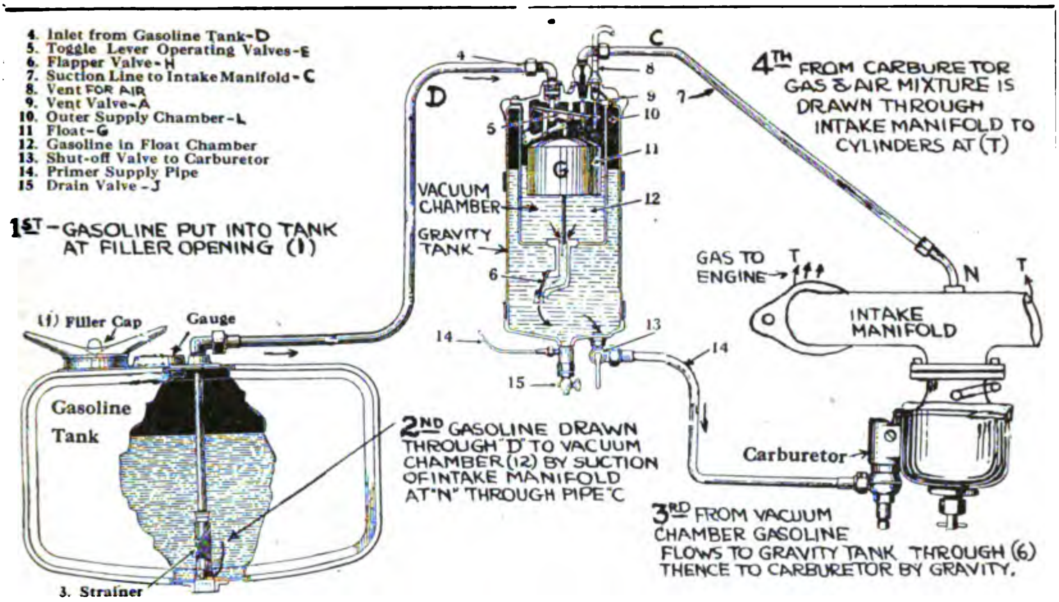
Carter Gasoline Pumping System.

Instead of drawing gasoline to the tank by a vacuum, the diaphragm pump (D) pumps the gasoline. E—connects with combustion chamber of cylinder by small copper pipe.

Compression causes diaphragm (D) to work in and the spring forces it back, causing a pumping action.

CHART NO. 81—Gasoline Feed Systems—simplified. **Attaching the Carburetor. Inlet Manifolds.**

See index for "Air Pressure Gasoline Feed System." ***When air pressure is used,** if carburetor has a small float the pressure should not be over 2½ or 3 lbs. With a larger float, the greater area will withstand more variation in pressure.


4. Inlet from Gasoline Tank-D
5. Toggle Lever Operating Valves-E
6. Flapper Valve-H
7. Suction Line to Intake Manifold-C
8. Vent FOR AIR
9. Vent Valve-A
10. Outer Supply Chamber-L
11 Float-G
12. Gasoline in Float Chamber
13. Shut-off Valve to Carburetor
14. Primer Supply Pipe
15 Drain Valve-J
1ST-GASOLINE PUT INTO TANK AT FILLER OPENING (I)
(I) Filler Cap
Gauge
Gasoline Tank
3. Strainer
D
VACUUM CHAMBER
GRAVITY TANK
G
C
4TH FROM CARBURETOR GAS & AIR MIXTURE IS DRAWN THROUGH INTAKE MANIFOLD TO CYLINDERS AT (T)
GAS TO ENGINE T
N
T
O
INTAKE MANIFOLD
Carburetor
2ND GASOLINE DRAWN THROUGH "D" TO VACUUM CHAMBER (12) BY SUCTION OF INTAKE MANIFOLD AT "N" THROUGH PIPE "C
3RD FROM VACUUM CHAMBER GASOLINE FLOWS TO GRAVITY TANK THROUGH (6) THENCE TO CARBURETOR BY GRAVITY.

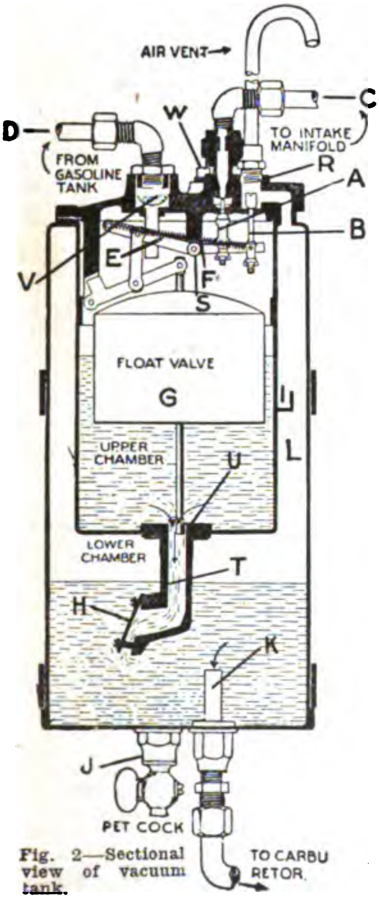


Fig. 2—Sectional view of vacuum tank.

The Stewart Vacuum Gasoline System.

Referring to upper illustration it will be noted that gasoline is fed by gravity to carburetor in the usual manner, by a gravity tank, which is combined with a vacuum system of drawing the gasoline from the main gasoline tank. In other words the same gravity principle of feeding gasoline to the carburetor is utilized but the auxiliary or gravity tank and the vacuum suction system is placed on the inside of the dash (usually) above and near the carburetor, so that the gasoline will feed to the carburetor at all times regardless of the angle or position of car.

The difference in this system is that of drawing the gasoline to this tank, as the main gasoline tank is below the level of the gravity tank. Instead of air being applied to the gasoline in the main tank to **force** the gasoline to the gravity tank, **it is sucked by a vacuum process** through pipe **(D)** to the vacuum chamber **(12)**, thence it flows through trap or flapper valve (6) to the gravity tank, thence to carburetor.

This vacuum is created by suction at intake manifold through pipe C, connected at N.* We know that a great suction takes place in the intake manifold when pistons are working. Therefore this suction is utilized to create the vacuum as will be explained below.

Principle of Operation.

There are two chambers; the upper or vacuum chamber and the lower chamber or gravity feed tank.

When there is no gasoline in either chamber, the float and levers E and F, to which float is connected, **closes** the valve **B** which admits air into the vacuum chamber and at the same time **opens** the valve **A** connected with the suction pipe **C** which is connected with the intake manifold.

If engine is working, (by crank or power), a vacuum is then created in the upper chamber which closes the flapper **H** (by suction), thereby making upper chamber absolutely air tight, which creates a vacuum and causes the gasoline to be drawn from main gasoline tank to vacuum or upper chamber.

As the gasoline enters upper or vacuum chamber the float rises, and through lever **E** and **F**, connected to float, the valve **A** to intake manifold is closed, thereby cutting off further suction and at the same time valve **B** is opened, which permits air to enter the vacuum chamber, through air vent tube.

Air entering vacuum chamber causes flapper **H** to open which action permits the gasoline in vacuum tank to flow into the lower chamber or gravity tank, thereby causing the float to lower as the gasoline flows out.

As the float lowers, the operation of levers **E** and **F** is again brought into action, and valve **A** is again **opened** and **B closed,** which again causes **H** to close, and the vacuum and suction takes place again, as explained above. **It will be noted that the lower chamber is always open to air circulation** through the "air vent tube," otherwise the gasoline would not flow by gravity to carburetor.

***Note—although connection of pipe (C) is shown in center of manifold at (N), the usual plan is to connect it near end of manifold,** as the vacuum is greater at a point closer to one of the cylinders.

Primer (14) above, is a connection used by some of the car manufacturers for connecting with hand pump on dash, similar to fig. 10, page 156, for priming engine to start during cold weather.

CHART NO. 81-A—The Stewart Vacuum Tank and Gravity Feed to Carburetor. Manufacturer are Stewart-Warner Speedometer Corp., Chicago, Ill.

INSTRUCTION No. 13.

*CARBURETOR ADJUSTMENTS; Parts to Adjust. Carburetor Troubles. Adjustments of Leading Carburetors.

The principle of carburetion is treated in instruction No. 12, and it will be advisable to start at the beginning of the subject and master the fundamental principles before taking up the subject of adjustments in this instruction.

Kerosene carburetors for marine and stationary engines, are described elsewhere in this instruction (see index). And motorcycle carburetors are described in **Dyke's Motor Manual.** Ford carburetors are described under Ford instruction.

A Few Words on Adjustments.

First and most important thing to learn about any carburetor is to let it alone as long as it is working properly. Never tamper with the carburetor until you are quite sure that it is at fault.

Test engine for compression, see that there is a good **hot spark** occurring in each cylinder at the right time, and gasoline in the tank. The carburetor should be the **last** thing to touch.

If the engine refuses to start, first flood the carburetor by holding down the tickler above the float chambr; if gasoline does not appear, look for a leak or an obstruction in the pipe; a closed shut-off valve or a dirty strainer.

If the tickler shows gasoline in the float chamber look for trouble in the clogged spray nozzle.

If the carburetor floods or leaks gasoline when the car is standing, look for an obstruction under the float valve or a leak at one of the connections.

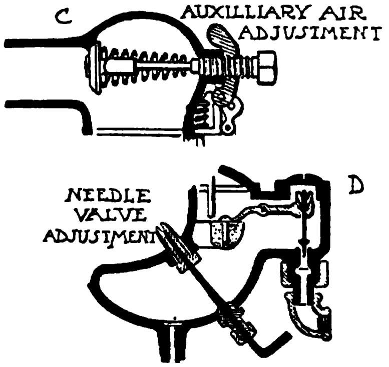
If the engine starts, but a "popping" noise occurs in the carburetor when the throttle is suddenly opened, it indicates a **lean mixture.** Open the needle valve slightly or put in a larger jet if there is no needle valve.

If the engine runs sluggishly with a black smoke at the exhaust, it indicates too rich a mixture. Close the needle valve slightly.

If the engine refuses to idle properly, or lacks "ginger" or "pep" at the higher speed, close the air adjustment slightly, and if not already too rich at low speed, the gasoline needle valve may also be opened slightly by turning to the left.

Parts to Adjust—Air Valve Type.

The three principal parts of a carburetor used for making adjustments are: the **auxiliary air valve,** the gasoline **needle valve** and the float mechanism.



Three principal parts of an air valve type carburetor for adjustments.

Some carburetors do not have auxiliary air valves, but depend upon the main air supply opening and a "gasoline needle valve" for adjustment. For instance; the Kingston Model "Y" on the Ford (page 160); the usual method of adjusting this carburetor is to start the engine, advancing the throttle lever to about the sixth notch with the spark retarded.

The flow of gasoline should now be cut off by screwing down the needle valve until the engine begins to miss-fire; then gradually increase the gasoline feed by opening the needle valve until the engine picks up and reaches its highest speed, and until no trace of black smoke comes from the exhaust. Having determined the point where the engine runs at its maximum speed, the needle valve is left adjusted at this point. There are other carburetors which do not have "auxiliary air valves" or "needle valves" to adjust. This and other types will be explained further on.

*Float Troubles and Adjustments.

When a carburetor drips this usually indicates the float or float valve mechanism is out of adjustment. This prevents the float needle valve from properly closing. For instance, the float may be loose, as shown in illustration, at the float screw, the gasoline then reaches a higher level than the spray nozzle or jet— result, overflowing at the spray nozzle.

---

*See index for "Digest of Troubles;" for carburetor troubles, in addition to pages 170 and 171

There are several causes for a dripping carburetor; either the float needle valve does not seat; due to sediment under it, or perhaps it is worn. If sediment is the cause, the needle valve can be turned a few times on its seat and probably clear the obstruction. On some carburetors, the float-needle-valve is in the form of a rod running through the float, as in fig. 1, page 148.

If the leak is not in the float-needle-valve, then it is likely due to the **float being set so that it does not cut off in time** to prevent overflowing at the jet. Or if a metal float; **there may be a small hole in it** preventing it from floating; another cause might be due to the **mechanism being too loose.**

Float adjustment: There is usually an adjustment provided directly above the gasoline float needle valve, which will regulate the height of the float. If not, then on some makes of carburetors, as the Schebler, for instance, the float arm can be bent up or down which will regulate the height of float, which in turn governs the float needle valve cut off.

If the leak is due to a faulty seating of the float needle valve, then it will be necessary to put in a new needle valve or to reseat the float valve seat or both.

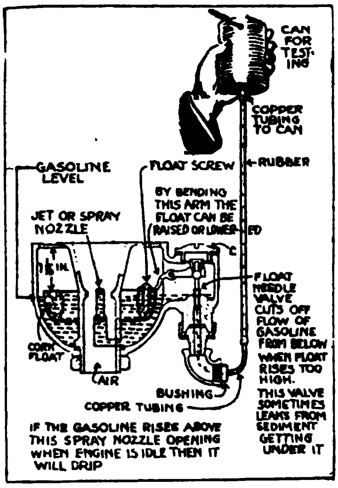

CAN FOR TESTING
COPPER TUBING TO CAN
RUBBER
GASOLINE LEVEL
FLOAT SCREW
BY BENDING THIS ARM THE FLOAT CAN BE RAISED OR LOWERED
JET OR SPRAY NOZZLE
1/8 IN.
C
FLOAT NEEDLE VALVE CUTS OFF FLOW OF GASOLINE FROM BELOW WHEN FLOAT RISES TOO HIGH.
THIS VALVE SOMETIMES LEAKS FROM SEDIMENT GETTING UNDER IT
CORK FLOAT
AIR
BUSHING
COPPER TUBING
IF THE GASOLINE RISES ABOVE THIS SPRAY NOZZLE OPENING WHEN ENGINE IS IDLE THEN IT WILL DRIP

Fig. 1. Regulating the float level in a carburetor; gasoline must stand in the jet barely below level of jet or spray nozzle, when the float cuts off.

By slightly lowering the float the adjustment can be made to cut off **early.** Raising float will cut off **later.**

Testing the Float Height.

On most makes of carburetors, the **float valve is intended to cut off** the gasoline when the level of gasoline in the float chamber **reaches a level of about 1/8 of an inch below the top of the nozzle or jet tube.** Therefore this height or the height recommended by the manufacturer ought to be maintained.

A simple method to test a carburetor float mechanism is shown in the illustration.

In making this test, unscrew the part of carburetor which will permit access to the float and float-mechanism. Then prepare a device consisting of a can with a wire handle, a piece of copper tubing soldered to the bottom of the can to form an inlet, a piece of rubber tubing, and a nipple or short piece of metal tubing with a coupling adapted for attachment to the carburetor. The gasoline flows to the carburetor from the can, when it is held above the carburetor. By watching the float chamber fill with gasoline, the height the gasoline reaches at the time the float valve cuts off can be seen. **If the height of gasoline in carburetor is not sufficient,** then the float is **slightly raised** so it will cut off later, if **the height is too great,** which can be determined by gasoline flowing out of the jet, then the **float** must be **slightly lowered,** so it will cut off earlier.

Owing to the variation in the suction of different engines on a carburetor, it often is found that a slight variation of the fuel level or a slight change in the size of the spraying nozzle will add greatly to the efficiency of the engine. The first thing to do then before attempting the adjustment of a float is to learn whether or not the float needs adjustment, by seeing if the gasoline is at the proper height in the jet when the float cuts off the gasoline.

To locate a suspected leak in a float of the hollow metal type:

If the float is immersed in very hot water, the gasoline will be vaporized sufficiently to force its way out through a puncture and the spot may be located by watching the bubbles. The float should, of course, be removed from the water the instant bubbles cease appearing. The remedy is to solder the hole. (see page 163.)

Gasoline Level in the Jet.

Stromberg: Note level of gasoline in float chamber in the Zenith, fig. 2, page 168. This illustration will give the reader an idea as to the relation of the level of the gasoline in the float chamber to that in the jet. On the Stromberg (H) it should be about one inch from the lower edge of the glass. This can be adjusted by removing the dust cap and loosening the nut; if gasoline is too low, screw adjustment up; if gasoline is too high, screw adjustment down.

†The adjustment on the Stromberg "K" type can only be adjusted by "bending the arm," as previously explained, which governs the float level.

Rayfield: The float level is correctly set at the factory and does not require adjustment, but if it should, then the correct gasoline level should be maintained in the middle of the window in the side of the float chamber.

---

*It is advisable to not tamper with the float unless you know positively it is out of adjustment. This can be determined if continually leaking and test as above. Carburetors with floats as per type "H" Stromberg are provided with float adjustments.

†**On models L & M Stromberg carburetors,** page 176-177, the height of gasoline should be 1 inch below the top of the float chamber.

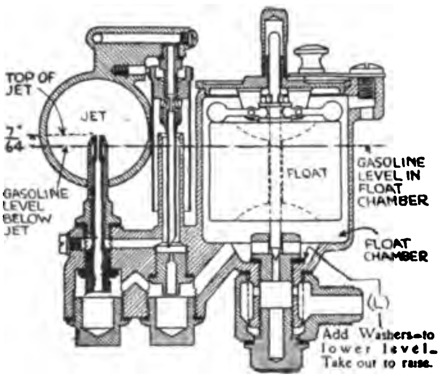

TOP OF JET
JET
7"/64
GASOLINE LEVEL BELOW JET
FLOAT
GASOLINE LEVEL IN FLOAT CHAMBER
FLOAT CHAMBER
(L)
Add Washers—to lower level. Take out to raise.

Fig. 2. This illustration shows the level of gasoline in the float chamber and in the jet of the Zenith carburetor. If the float level was above the jet, the gasoline would run out the jet.

Zenith: The level of gasoline is maintained in the float chamber so that the gasoline stands 3 millimeters below the top of the jet, or about 7/64". To regulate the level, note the washers (L), fig. 2.

Master: The float weights are set about 1/32 inch from bottom of the float lid.

Schebler: Model "L" (chart 84); the top of the cork should stand 1 1/16 inch from the top of the bowl in the 1-inch, 1¼-inch, 1½-inch and 1¾-inch. In the 2-inch—model L carburetors this measurement is 1⅛-inch and in the 2½-inch model L, 1⅝-inch. These measurements should be made when the float valve is seated.

Model R; the height of the cork float should be 23/32 inch from the top of the bowl when float valve is seated.

Models D & E; the cork float should be level and rest 1/16 inch above the top of the nozzle in the ½ inch, ¾ and 2 inch sizes, and 1/32 inch on the 1, 1¼, and 1½ inch sizes. Model H; is 19/32.

Note, when changing float level, great care must be taken to bend the arm in such a manner that the float will be at the proper height, yet perfectly level.

Auxiliary Spring Tension Adjustment.

In the air valve spring lies the chief difficulty in making carburetor adjustments, if carburetor is provided with automatic auxiliary air valve. This spring should be of such length and of such gauge wire, diameter and number of convolutions as to provide the requisite progressively increasing resistance to opening, while at the same time exerting little or no pressure upon the valve when it is against its seat.

Adjustment: The needle valve should be set for slowest running with the air valve held lightly against its seat, and then the spring adjustment should be backed off until the slightest further increase in throttle opening causes the valve to leave its seat.

From this point on the only proper adjustment for the air valve becomes a series of tests for spring strength without alterations being made in its normal length. That is, with the adjustment backed off as per the above instruction; if the spring tension with increased throttle openings is too light and "spitting back" in the carburetor continues in spite of increased opening of the gasoline needle valve adjustment; it is a pretty sure indication that the air valve spring is too weak and a stronger one should be obtained from the factory. These can usually be obtained in several sizes or degrees of tension to suit varying engine and climatic conditions.

Too strong a tension on the auxiliary air valve spring will cause **too much gasoline** and not enough air (too rich a mixture), because the valve will be more difficult to open by suction. **Too weak a spring tension** will give too much air or too lean a mixture.

The hand air adjustment operated from the seat is very popular. See pages 159, 155. The warmer the engine the more air needed and less gasoline. By merely opening the air intake more and more, by hand, the proper mixture can be obtained.

**A Few Words About the Mixture.

***At low speeds** the mixture should be richer than at high. At low speeds more heat is lost to the cylinder walls, more compression is lost by leakage, and the combustion can therefore be slower, thus sustaining the pressure. **At high speeds** the compression is higher, due to less leakage and less loss of heat. A lean and highly compressed charge burns faster and hence gives better pressures and fuel economy than a richer one.

The quantity of mixture an engine will take, varies greatly with the speed and pull. At slow speeds the volume, at carburetor pressure is equal to the cubic content of the cylinders, multiplied by the number of power strokes.

At high speeds of one thousand revolutions or over, the quantity may drop to less than one-half the amount, depending on the design of the valves, inlet piping and passages. This reacts upon the compression, and hence on the mixture desired for best results.

****The plug points or gaps should be carefully set;** about .025 of an inch apart. **If too close** engine will operate unevenly at idling speeds and miss at higher speeds; **If too wide,** will miss when accelerating at very low speeds or hard pulls. A weak spark causes late combustion. See index for "Spark Plugs."

****Atmospheric conditions have much to do with action of carburetor.** An engine seems to run better at night (see page 585)—likewise, taking an engine from sea level to an altitude of 10,000 feet, involves using air in the engine cylinders at atmospheric pressures ranging from 14.7 lbs. down to 10.1 lbs. to the square inch.

The design of the engine has a bearing on the carburetor design, which explains the well known but seemingly mysterious fact, that a carburetor giving good results on one engine sometimes fails to maintain its reputation when applied to one of different design. The system of ignition used also has a marked influence on the proper working of an engine as a **hot spark is most essential.**

To Test the Mixture.

If there are doubts in the mind of the operator as to whether the mixture is too rich, **an excellent way to ascertain the correct proportion of air and gasoline is to shut off the fuel at the tank and open the throttle.**

If the mixture passing into the cylinder is too rich, the engine speed will increase as the level of the gasoline in the float chamber is lowered, since this operation weakens the mixture considerably.

If the mixture is thought to be too weak, the float chamber can be flooded while the engine is running, and if this causes the engine to speed up, it may be taken as an indication that the mixture is not rich enough.

The proportionate amount of gasoline to the proportionate amount of air is essential.

The novice usually gives the carburetor too much gasoline by opening this adjustment valve too wide, thereby causing "too rich a mixture." Too much gasoline will not run the engine any better than not enough. It must be remembered that only a very little gasoline is required in proportion to the air.

‡Smoke Tests.

If the engine is fed too much gasoline, **black smoke,** smelling of raw gasoline, will usually be in evidence, issuing from the exhaust. Care should be taken to distinguish this from the excess of heavy **blue smoke** which is indicative of too much engine lubrication.

Whenever any considerable quantity of smoke of either color come from the exhaust, the engine may miss explosions due to **fouled spark plugs.**

***If the mixture is too rich, the engine will have a tendency to slow up and "choke" or "load up" when the throttle is opened wide, and will run at a higher speed when it is partially closed.**

Another indication of the mixture being too rich will be shown in its speeding up perceptibly, if the **auxiliary air valve** of the carburetor is held open, or additional air is admitted in any way between the carburetor and the cylinders.

Such being the case, the exhaust gases, if ignited by holding a piece of burning paper near the end of the exhaust pipe, will burn with a large red flame similar to that of a bunsen burner when the air is mostly cut off.

****Loping:** Another indication of too rich a mixture is when **"idling;"** the engine **will run in a loping manner as if actuated by a governor; more air,** less gasoline is needed.

Flame Test of Mixture.

Another method is to open the relief cocks in the cylinder heads (if provided), while the engine is running and judge from the color of the flame when the mixture is correct. At each explosion a jet of flame will shoot out of the cylinder through this relief cock.

If the mixture is too poor—too much air for the gasoline—the **flame will be light yellow.**

If the mixture is too rich—not enough air for the gasoline—**the flame will be red and smoky.** Black smoke will also come out of the muffler, smelling of raw gasoline.

If the mixture is correct, the flame will be **light blue,** and hardly visible.

†Rich and Lean Mixture.

A rich mixture is one in which the proportion of gasoline abnormally exceeds the amount of air. It may be due to faulty adjustment of the gasoline needle valve, float, or air valve.

An overrich mixture will cause an engine to overheat and thereby give rise to a number of troubles such as; preignition, accumulations of carbon on the pistons and cylinder heads, steaming water in radiator and loss of power and **"loping" or choking up on slow speeds.**

A mixture is poor or lean when it contains too much air and not enough gasoline, a condition often due to a faulty adjustment of the needle or air valve float, **a leak** in the inlet pipe, the supply cock partly shut off, the spray nozzle, float valve or feed pipe partly clogged, or water in the gasoline.

A poor mixture will make the engine miss when running idle at slow speeds, and at high speeds it will not only cause misfiring, but the missing will be accompanied by coughing and **"popping"** in the carburetor. Both this and explosions in the muffler may also be due to faulty ignition, however.

Cause—mixture too rich: Too much gasoline at needle valve. Punctured float. Float valve not working properly, owing to bent needle, or presence of foreign matter in valve seat. Too much priming. Primary air passage clogged or partially obstructed. Air valve not open enough, spring too strong or air opening choked.

Cause—mixture too weak: Too much air, not enough gasoline. Carburetor passages or jet clogged. Throttle valve out of adjustment. Insufficient flow of gasoline. Tank valve closed. Break in gasoline supply. Bad gasoline; originally, or from standing. Water in gasoline. Carburetor too cold. Gasoline supply exhausted.

***Mixture "too rich" means too much gasoline in** proportion to air, or technically, there is **insufficient oxygen to support its combustion.**

**See page 171. ‡See also pages 652, 653. †See page 623, "relation of carbon to combustion."

"Loading up" when running slow or idling is due to the fact that the air comes into the carburetor so slowly that the gasoline particles are not broken up fine enough and condensation takes place. Thus the gasoline is taken in, in a more or less liquid form and combustion is very poor. That is one reason why as much heat as possible should be applied to the air intake of the carburetor. Also do not let your engine tick over slowly for any length of time when the car is standing idle. It not only wastes fuel but the manifold will load up with raw fuel and your acceleration will be anything but good when you attempt to get under way. See also page 652.

Use air: It is advisable to run the engine with as much air as possible, which means a "lean" mixture. This not only means economy of gasoline but prevents soot deposit and pitted valves (providing good lubricating oil is used).

Of course, when first starting or when cold, more gasoline is absolutely necessary, but as soon as the engine warms up, cut down on the gasoline and run on **more air.**

Most carburetors now-a-days, are fitted with air regulators and heated intake manifolds, as shown on pages 157 and 159, for this purpose.

An engine will run on less gasoline, and more air, the warmer it gets. Therefore the reason for the air adjustment.

"Back Firing" or "Popping" in the Carburetor.

Back firing: There seems to be much confusion in the use of the terms "back kick" and "back fire," the latter being very often used to describe what happens when, in starting an engine, it suddenly reverses its direction of rotation to give a "back kick."

Generally speaking, "back-firing" is caused by weak mixture which burns so slowly that the flame continues until the opening of the admission valve again, when it ignites the incoming charge in the intake pipe and shoots back to the carburetor. While an over-rich mixture will also burn slowly, it rarely ever will cause back-firing.

Another cause of back-firing is, of course, the faulty timing of the valves, or, in fact, a badly leaking valve. As a general rule, back firing is due to one or more of the following causes: (1) very slow explosion or weak mixture, (2) very late explosion; (3) a spark occurring during the intake stroke; (4) the intake valve partially open during the power stroke; (5) premature ignition.

Slow combustion is caused by a lean mixture. **A late explosion** is caused by a weak or retarded spark.

Nos. 1 and 2 are the usual causes, while Nos. 3 and 4 happen infrequently.

Back-kicking is usually caused by preignition in starting the engine, which is due usually, as is well known, to too much "advance" in the spark timing.

"Popping back" or "spitting" in the carburetor is quite a common occurrence with carburetors when first starting the engine on a cold day. But after engine has been run for a brief period it will become warmed up and the gasoline will begin to vaporize properly and run without popping back.

If the "popping back" continues then the **mixture is too weak** and more gasoline is required. By giving the auxiliary air valve spring a slight increase of tension or opening the gasoline needle valve a notch or so, to close the "damper" or air intake, thereby causing more gasoline supply until the popping stops, which it will probably do when engine is warmed up.

Carburetion During Cool Weather.

Now that low gravity gasoline is being used, the engine will have a tendency to miss explosion and run in jerks or uneven explosions, especially when starting.

The reason is due principally, to the **lack of heat** to properly vaporize the gasoline to prevent condensation. After the engine becomes thoroughly warmed up, the missing usually disappears. When weather is warm the engine starts easier, because gasoline will vaporize more readily and is easier ignited. Therefore during cool weather **three things are essential;** a good **hot spark** and a **quick method of heating** and a **choker** or **primer** for enriching the mixture to start on.

****For starting**—There are different methods employed to inject a rich mixture into cylinder in order to start engine at all on a cold day. The common method is to close the main air intake, which causes raw gasoline to be drawn into cylinder, which would be termed "choking" the air supply. **After engine is started,** it is then a matter of running engine until warm enough to vaporize the gasoline, at the same time gradually opening the choke or air valve, until the regular amount of air is being used.

Warm air, of course should be drawn into the carburetor as per fig. 1, page 159. If a temperature regulator is also provided, as per fig. 2, page 159, then less cool air should be drawn in at (Z) in winter, than in summer.

There is a disadvantage however, in this system, and that is, the raw gasoline drawn into a cool cylinder is not all utilized for combustion, but part of it forms carbon, due to lack of oxygen which is not being supplied, as the air is choked, result, as per page 205. Therefore the air should be supplied as quick as possible. **The problem is then, to heat the gasoline as quickly as possible,** so that vapor and air is used **instead of raw gasoline.**

The exhaust heated intake manifold, explained on page 155 and 157, will assist considerably. With a jacket around the intake manifold, and hot exhaust gases passed through same, as per page 157, the mixture will become heated quicker.

The **choker** or some method of supplying a richer mixture however, is usually necessary for starting. If the "choker" principle is used, it is closed **only until engine** starts, then gradually opened. **In fact, by using an exhaust heated intake manifold to heat the mixture, and also drawing warm air through air passsage of carburetor** as per fig. 1, page 159, the amount of raw gasoline injected into the cylinders will be considerably less than if same is not heated. Therefore this system will provide a quicker vaporizing or heating of mixture and a saving of fuel and less carbon deposit in cylinders.

Additional Pointers on Cold Weather Starting.

Don't expect the engine to warm up in a minute any more than you expect a kettle to boil as soon as it is set on the stove. It takes time to heat.

Take into consideration the fact that cold solidifies the lubricant in the transmission, rear axle, and other parts of the car. Therefore, it requires greater energy on the part of the self-starter to revolve the engine.

If the clutch is in, you of course revolve most of the transmission gears. After a car has been standing over night in a cold garage or sufficiently long at the curb to become thoroughly chilled, **throw out the clutch** when cranking. This eliminates the drag of the transmission gears plowing through the solidified grease.

A good hot spark is important, especially in winter. Remember it is more difficult to charge a battery in winter than in the summer, so be particular to see that the battery is always charged. A quick method of starting should be provided in order to save current.

---

*See page 576 "Digest of Troubles," also foot note, page 153.

**See page 798 for starting Ford carburetor in cold weather. The method employed here is to open gasoline needle valve slightly in extreme cases and close damper also. See also page 160.

†Adjusting the Average Air Valve Carburetor.

Carburetors are usually adjusted to the best advantage when the engine has been run and all parts are warmed up. If a carburetor is adjusted when the engine is cold, it will be noticed that it will need readjusting when warm, that is, in order to get a perfect adjustment.

When carburetors are adjusted when warm, sometimes, especially on a cold day, the engine will not hit just right when first starting; it will miss and not run even or smooth until it has run a few moments and is heated up, then it runs satisfactorily.

***Another point to remember, be sure the ignition is right and you have a good hot spark, and spark plug gaps set about .025 of an inch** (see index for "adjusting spark plug gaps"). Also be sure the trouble is in the carburetor and not due to other troubles. See "Digest of Troubles," how to diagnose troubles.

For the average carburetor, having an "auxiliary air valve" and a "needle valve" adjustment, the following rule for adjusting will apply.

First, run the engine at what will be nearly its maximum speed in ordinary use with the throttle open considerably and the spark rather late. This speed, of course, will be considerably less than the maximum speed of the engine when running idle.

Second: Then turn the main gasoline adjustment, until the mixture is so weak there is popping in the carburetor.

Third: Note this position and then turn the adjustment until so much gas is fed that the engine chokes and threatens to stop.

Fourth: Set the adjustment half way between these two points, which will be very near the correct position. Turn the adjustment slightly in one direction and then in the other until the point is found where the engine seems to run the fastest and smoothest.

Fifth: Gently and gradually cover the auxiliary air inlet of the carburetor by placing the hands over the valve, if necessary, in order to exclude the air. If the **engine slows down,** the **spring** should be **weakened,** since not enough air is allowed to enter the carburetor.

Sixth: Next try opening the air inlet slowly and gradually by pushing the poppet off its seat with the finger or the end of a pencil. If the engine speeds up, there was not enough air and the spring should be loosened, while if it slows down, the mixture is correct or a little too lean, according to the degree to which the speed is affected. If it is found to be **too lean,** the **spring** needs **tightening.**

Seventh: After the air inlet has been adjusted, open the throttle again and adjust at high speed, as this adjustment may now require to be altered.

When adjusting carburetors for speed, racing, etc., the mixture is cut down much more than for ordinary use. One method is to cut off the supply until the engine misses when idling at low speed. Then give it just a trifle more and test the adjustment by trying the car on a hill.

Some time ago the writer was told by an ex-tester that whenever he was beaten in a "brush" he was in the habit of stopping and adjusting his carburetor until the engine missed, and then give just a slight turn more on the gasoline needle valve. Then, in a good many cases, he was able to catch up with and pass his opponent.

The best way to adjust a carburetor is to arrange so that the engine may be run loaded while the adjustment is being made. One way to do this is to adjust the carburetor while the car is in motion on the road, tor while the car is in motion on the road.

To test carburetor for adjustment; run throttled down for two blocks. When there is a clear space ahead, suddenly press accelerator pedal down. The engine should pick up smoothly, to as high speed as you care to run. If engine chokes, stalls, misses or labors, or backfires at carburetor, or muffler explosions, it shows the carburetor is out of adjustment.

To Obtain a Slow Even Pull of Engine Without Missing.

(1) **Retard the ignition.** If this does not overcome the missing and it is not due to other causes mentioned below, it may be due to the ignition being set too far advanced at retard position. Setting back a tooth will often help to run slow, if this is desirable.

(2) **Air leaks** is a common cause. Be sure there are no leaks at intake manifold and carburetor gaskets, valve caps and above all, use **good **spark plugs** (see page 235) and see that they do not leak at bushing and where screwed into cylinders. See that gaps are about .025. This is important. Wide gaps and weak magnets on magneto ignition will cause missing.

(3) **Interrupter points** must be set correctly. A clear flat surface is important.

(4) **Be sure there is a good hot spark from the battery,** which means a fully charged battery.

(5) **A coil has been known to have a short circuited internal connection** which would give a spark at high speeds but miss on low speeds.

(6) **The carburetor should be adjusted** which does not permit loping (too much gasoline). The hot exhaust heated manifold is an advantage here.

(7) **Engine should have good compression;** valves ground, and proper valve clearance, being sure valves are not held open too long. Rings free of leaks.

All this is esential to secure a flexible and smooth running engine.

Leading Carburetors,—Principle and Adjustment.

Are treated on pages following.

Owing to the fact that innumerable improvements are constantly being made in carburetor construction, it is impossible in this instruction to describe **all** the actual adjustments of **all** the carburetors.

Repairmen are advised to secure instructions for adjustment of all the leading makes of carburetors from the manufacturers and keep them on file (see page 162 for list of the leading manufacturers).

---

†See "Digest of Troubles" for carburetor troubles and remedies, page 576.

*See page 543 for "Specifications of Leading Cars" to find the type of carburetor used on different makes of cars.

**See page 233 for testing spark plug leaks.

†When adjusting "V" type engines, adjust each block of cylinders separate, by disconnecting one block.

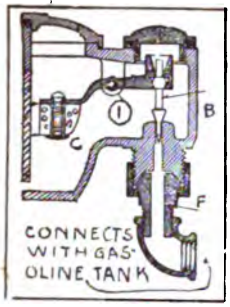


Fig. 1.

The parts consist of a float chamber (D), the cork float (C), and a float needle valve (B).

These three parts control all flow of gasoline into the carburetor as it is needed by the motor.

That part of the carburetor which mix . the gasoline and air consist of a mixing chamber (L), a nozzle (G), and a needle valve (I).

Parts which Automatically Regulate the Amount of Gasoline Required from the Float Chamber to Provide the Proper Mixture consist of an auxiliary air valve (A) and lever (H), connected with needle valve (I).

OPERATION; the Gasoline Flows from the Tank through the gasoline pipe into the float chamber (D).

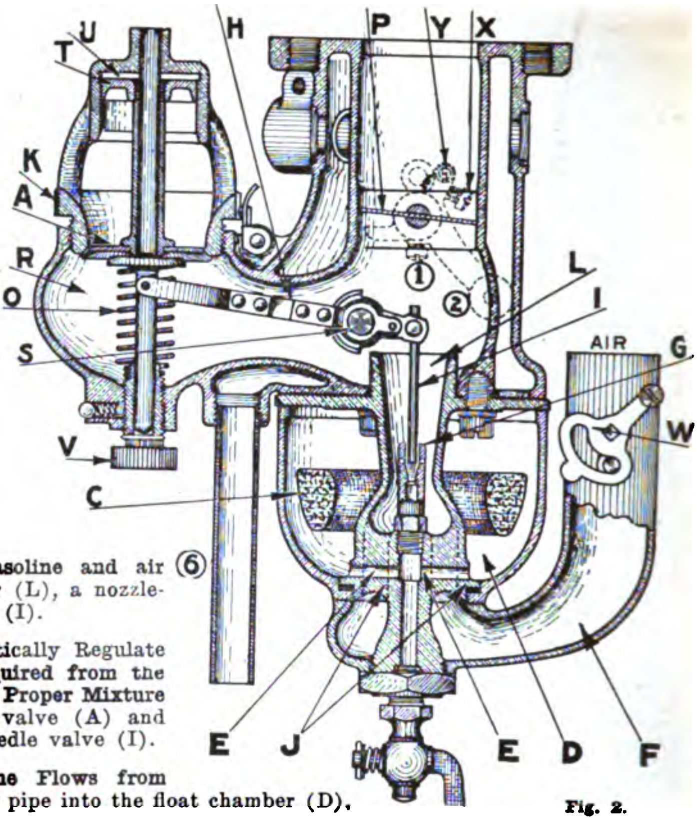


Fig. 2.

As the Gasoline Rises in the Float Chamber (D) it raises the cork float (C) with it, which, through a lever connection, automatically closes the needle valve (B) and shuts off the flow of gasoline from the tank to the carburetor. Of course as the gasoline is drawn from float chamber (D) the float (C) drops and raises valve (B), admitting more gasoline.

The Suction of the Pistons Draws the Gasoline from the Float Chamber (D) through the Passages (E) into the Nozzle Well (G), and past the needle valve (I) into the mixing chamber (L). As the needle valve (I) is raised and lowered as hereafter described, more or less gasoline is allowed to spray into the mixing chamber (L). At the same time the suction of the pistons draw from the warm air intake (F) and the passages (J), warm air into the mixing chamber (L). As the suction of the swiftly moving pistons is very strong, the air is drawn through the mixing chamber (L) with great velocity, and there, coming into contact with the gasoline spray from the nozzle well (G), it vaporizes the gasoline.

This Vaporized Mixture is then drawn by the suction of the pistons past the throttle valve (P) into the cylinders. The quantity of combustive vapor flowing past the throttle valve (P) is regulated by the position of this throttle valve, and the position of this throttle valve is regulated by the driver either from a pedal called the "accelerator" or a throttle lever on the steering post. Opening the valve (P) admits more combustive vapor to the cylinders, and consequently increases the speed and power of the motor. Closing it has the reverse effect. At high speed it is obvious that the suction through the mixing chamber (L) and the warm air passages (J) greatly increases, and as it increases beyond the capacity of these passages to supply air, a strong suction is brought to bear upon the auxiliary air valve (A). At a certain speed this suction is sufficient to draw this valve down against the coil spring (O). As the valve is drawn down, air rushes into the auxiliary air passage (R), and from thence past the mixing chamber (L) into the cylinders.

Auxiliary Air Valve. To take care of this extra supply of air there must be an extra supply of gasoline automatically furnished. This is taken care of as follows. As valve (A) is depressed against the spring (O) it operates the lever (H), which is hinged at the point (S). As the lever (H) is depressed by the valve (A) it opens needle valve (I) admitting more gasoline to the mixture. It can be seen that this extra supply of gasoline is always directly in proportion to the air supply through the valve (A).

Dash Pot Action. It is obvious that if means were not taken to prevent it the valve (A), which is under the tension of the spring (O), would close very abruptly if the speed of the engine was suddenly checked. It would also tend to open very abruptly if the speed of the engine was suddenly increased, as for instance, when the accelerator was suddenly opened. Furthermore, the suction of the cylinders is to a certain degree intermittent between the strokes of the pistons and this intermission between the strokes would ordinarily tend to cause the valve (A) to flutter or vibrate if means were not taken to prevent it, and the fluttering or vibratory action of the valve (A) would result in an unsteady flow of gasoline vapor to the cylinders, which would cause a vibratory or jarring effect in the engine. Any such action is prevented by a device (U) called a dash pot. Its function is to automatically insure a steady and staple supply of gasoline vapor to take care of varying engine speeds under all circumstances. To hold the valve (A) steady and to check its sudden closing or opening and to overcome its tendency to vibrate, it is attached directly to a plunger (T), which operates on a cushion of air in the dash pot (U).

NO. 82—Model "R" Schebler Carburetor. Note the gasoline needle valve is automat-rated by movement of auxiliary air valve (A). (See Specifications of Leading Cars for users.)

—model R continued.

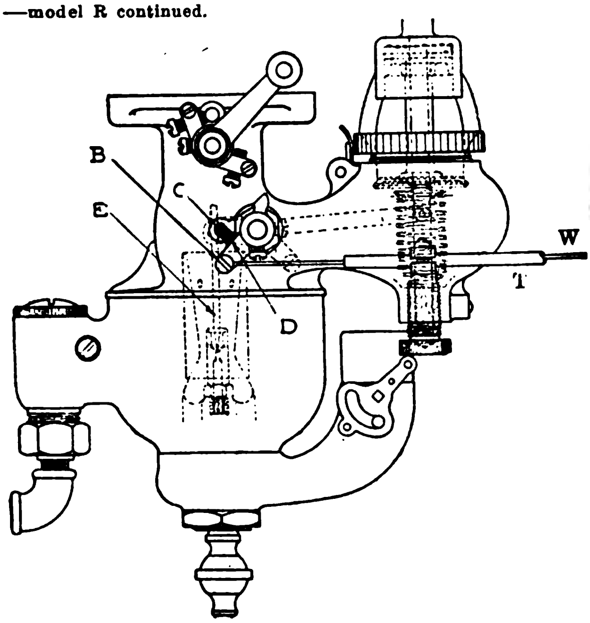


Fig. 3. When carburetor is installed see that lever "B" is attached to steering column control, or dash control, so that when boss "D" of lever "B" is against stop "C" the lever on steering column control or dash control will register "Lean" or "Air." This is the proper running position for lever "B."

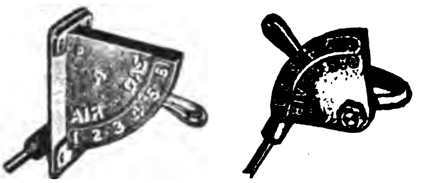


Fig. 4 and fig. 5, show two types of hand controls for "choking" air supply of carburetor controls. Fig. 4 shows the dash type and fig. 5 the steering column type.

Auxiliary adjustment—enables the driver to give the carburetor a very "rich" mixture without leaving the seat.

This adjustment is connected directly with the needle valve by means of an eccentric in the mixing chamber (see "S," chart 82) to which is connected lever (B), fig. 8. This lever is connected as shown, to the dash or steering column control by a flexible shaft (W) consisting of a piece of spring steel wire **running through** a brass tube (T) which is anchored firmly at the carburetor and soldered to the body of the dash or steering column control. By moving lever of the control the steel wire moves the lever (B) **when the lever on the dash adjustment is pulled all the way up it moves** the lever (B) to the right, or away from the stop (O).

The lever (B) turns the eccentric ("S," chart 82), **thereby lifting the needle valve** and increasing the tension on the air valve spring (O). This gives a very rich mixture for starting in cold weather and by gradually moving the dash control lever downward the **adjustment can be brought back to normal while the engine is running and getting warmed up.**

This adjustment is entirely separate from and independent of the main adjustments on the carburetor, which must be properly set before the dash or steering column adjustment is used.

In other words the carburetor **adjustments proper** are made at (K) and (V—chart 82) and after they are properly set, then the auxiliary adjustment can be used to get a rich starting mixture.

To adjust the carburetor (fig. 2), turn the valve cap (K) clockwise, or to the right (right means rich) until you can turn it no farther. Then turn to the left or anti-clockwise, (left means lean) through one complete turn. Start the engine and then continue to turn (K) to the left or anti-clockwise until the engine hits perfectly on all cylinders, at the slowest speed possible. Advance the spark lever two-thirds or three-fourths the way on the sector and then suddenly open the throttle lever or accelerator wide. If the engine back-fires on this quick acceleration, turn the spring adjusting screw (V) up until the carburetor works perfectly.

By turning the screw (V) up or inward, you turn it against the spring (O) (fig. 2), which increases its tension thus preventing valve (A) from admitting air into the carburetor too freely.

Turning (K) to the right or clockwise, lifts the needle valve (I) out of the nozzle well (G) and permits more gasoline to spray into the mixing chamber.

When you turn (K) to the left, or anti-clockwise it lowers the needle in the nozzle and shuts off the gasoline. It should be remembered that it is desirable from both the points of economy and power, **to drive the car with the leanest mixture possible.**

The throttle valve should be adjusted so that when the hand throttle is closed, the engine will just run evenly on all cylinders. This can be ascertained by the regularity of the impulses in the exhaust when both the spark and throttle levers are set at their lowest positions. If the engine, however, should run too fast, or should stop when the throttle is at lowest position, adjustment is necessary, directions for which are as follows:

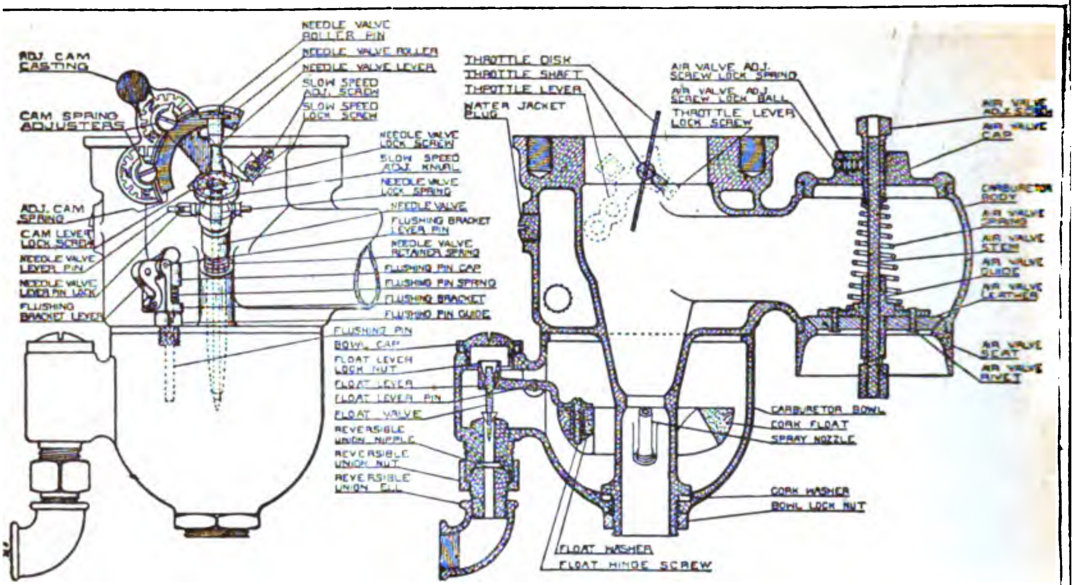
Loosen the set screw (X) which locks the adjusting screw (Y) where throttle shaft enters carburetor. Place throttle in lowest position.

If engine runs too fast, unscrew adjusting screw (Y) so that butterfly valve in carburetor is closed a little tighter.

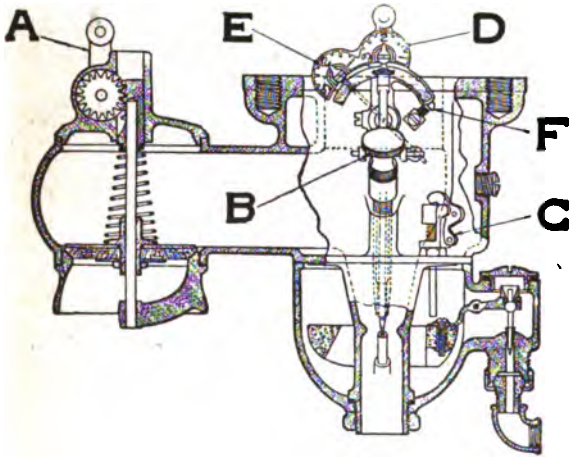
If engine runs too slow, screw in the adjusting screw so that valve is held a little more open. Lock adjusting screw (Y) with set screw (X) after adjustment.

Note: Warm air pipe as shown in fig. 4, chart 78A is connected with (F), fig. 2. The exhaust gas can be connected with (6), fig. 2, similar to fig. 2, page 157.

CHART NO. 88—Air Control and Adjustment of Model "R" Schebler Carburetor. (Wheeler & Schebler, Indianapolis)—see page 167 for "adjustment of floats."



Sectional View Model "L" Schebler Carburetor—Concentric type float, single jet and spring adjusted auxiliary air intake valve. Mechanically operated needle valve with three speed adjustments; low, medium and high.



Model L Schebler Carburetor.

Connect carburetor to intake pipe so that it sets about six inches below bottom of gasoline tank, that the bowl may be filled by gravity. For best results, the carburetor should be as close to the cylinder as possible, and in case of multiple cylinders, equidistant from each one. Connect a pipe or tube from gasoline tank to union "G." Pipe to be brass or copper and not less than ¼-inch hole.

Be sure pipe is free from dirt—blow it out. Connect the hot water jacket with water circulation if there is a force circulation, otherwise a hot air pipe. See Chart 78.

Before adjusting the carburetor, make sure that your ignition is properly timed and that you have a good hot spark at each plug; that your valves are properly timed and seated, and that all connections between your intake valves and carburetor are tight, and that there are no air leaks of any kind in these connections.

In adjusting the carburetor, first, make your adjustments on the auxiliary air valve "A" so that it seats firmly, but lightly; then close your needle valve by turning the adjustment screw, "B," to the right until it stops. Do not use any pressure on this adjustment screw after it meets with resistance. Then turn it to the left about a turn and a half and prime or flush the carburetor by pulling up the priming lever "C" and holding it up for about five seconds. Next, open your throttle about one-third, and start the motor; then close throttle slightly and retard your spark and adjust throttle lever screw "F" and needle valve adjusting screw "B," so that the motor runs at the desired speed and hits on all cylinders.

After getting a good adjustment with your motor running idle, do not touch your needle valve adjustment again, but make intermediate and high speed adjustment on the dial "D" and "E." Adjust pointer on the first dial, "D," from figure No. 1 toward figure No. 3, about half way between. Advance spark and open throttle so that the roller on the track running below the dials is in line with the first dial. If the motor back-fires with the throttle in this position, and the spark advanced, turn the indicator a little more toward figure No. 3; or if the mixture is too rich, turn the indicator back or toward figure No. 1 until you are satisfied that your motor is running properly with the throttle in this position, or at intermediate speed. Now, open the throttle wide and make your adjustment on your dial "E" for high speed in the same manner as you have made your adjustments for intermediate speed on dial "D."

Note:—We find in the majority of cases in adjusting this carburetor the tendency is to give too rich a mixture. We suggest and recommend in adjusting the carburetor, both at low, intermediate and high speed, you cut down the gasoline until the motor begins to back fire, and then increase the supply of fuel, a notch at a time, until the motor hits evenly on all cylinders. Do not increase the supply of gasoline by turning the needle valve adjusting screw more than a notch at a time, in your low-speed adjustment, and do not turn it any after your motor hits regularly on all cylinders. In making the adjustments on the intermediate and high speed dials, do not turn the pointers more than one-half way at a time between the graduated divisions or marks shown on the dials.

NO. 84—The Model "L" Schebler Carburetor; Hand Controlled, Mechanically Operat Valve. (See page 167 for adjustment of float.)

Rayfield Principle.

Rayfield carburetors are made in two types; model G and L, the difference being that model G has a water-jacket.

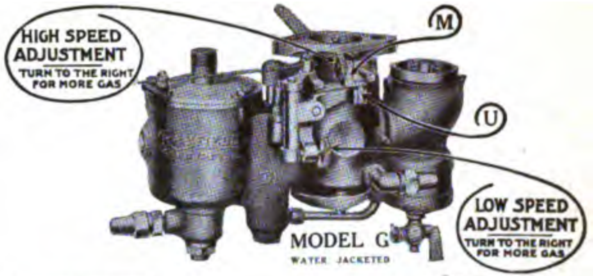
In both models the **air valve adjustment has been eliminated,** high and low-speed adjustments being made through the control of the fuel.

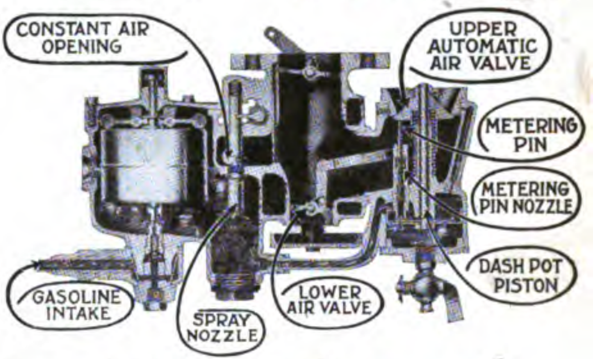
Both models are of the **two-jet type,** one jet feeding at low-speed and both at high-speed.

There are **three air openings,** one fixed and operating in conjunction with the low-speed nozzle and the other two having automatic valves linked together and operating simultaneously.

The high-speed nozzle is controlled by a metering pin actuated by the upper automatic air valve. The stem of the valve is connected to a piston working in the dash pot, from which a passage communicates with the float chamber; the dash-pot chamber has direct connection with the high-speed nozzle (see page 151).

When the throttle is opened, the tendency of the air valve to open suddenly and excessively, and to flutter, is checked by the dash-pot piston, which at the same time forces an extra supply of fuel into the nozzle and enriches the mixture for acceleration; the slow opening of the air valve increases acceleration by causing strong suction on the nozzles.

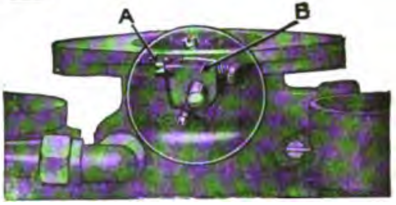




When adjusting a Rayfield carburetor, bear in mind that BOTH ADJUSTMENTS ARE TURNED TO THE RIGHT FOR A RICHER MIXTURE as indicated on adjustment screw heads.

The Rayfield dash control connects with carburetor by wire. When properly used, will render easy starting, furnish a richer mixture when engine is cold, and maintain a correct mixture under the extreme atmospheric changes.

When carburetor adjustments are once made, they should not be changed, as the dash control will take care of cold weather as well as cold engine conditions.



A.— Stop arm screw. B.—Stop arm. Turn screw A to left to throttle engine lower.

Raising the dash control lifts the spray needle and supplies a richer mixture. When it is raised full distance, a direct passage is opened permitting raw gasoline to be drawn from fuel chamber of the carburetor to engine. Control button (or lever) should be DOWN for running except when a richer mixture is desired.

The automatic air valve should be closed when engine is not running or when throttled down.

Remember that the **low speed adjustment** is to be used **only** when engine is running idle and positively must not be used in adjusting high speed. Never adjust a carburetor unless the engine is hot and the water jacket of carburetor warm.

Adjusting Rayfield.

Adjusting low speed: With throttle closed, and dash control down; close nozzle needle by turning LOW SPEED adjustment to the LEFT until block U (see cut), slightly leaves contact with the cam M. Then turn to the RIGHT about three complete turns. Start engine (see below) and allow it to run until warmed up. Then with retarded spark, close throttle until engine runs slowly without stopping. Now, with engine thoroughly **warm,** make final low speed adjustment by turning low speed screw to LEFT until engine slows down and then turn to the RIGHT a notch at a time until engine idles smoothly. If engine does not throttle low enough, turn stop arm screw A (see cut), to the LEFT until it runs at the lowest number of revolutions desired.

Adjusting high speed; advance spark about one-quarter. Open throttle rather quickly. Should engine back-fire, it indicates a lean mixture. Correct this by turning the HIGH SPEED adjusting screw to the RIGHT about one notch at a time, until the throttle can be opened quickly without back-firing. If "loading" or (choking) is experienced when running under heavy load with throttle wide open, it indicates too rich a mixture—this can be overcome by turning high speed adjustment to the left.

To start engine when cold: First: Close the throttle and pull dash control all the way up. Second: When engine starts, open throttle slightly and push dash control one-quarter of the way down. Third: As engine warms up, push control down gradually as required. When thoroughly warm, push control all the way down. When engine is warm it is necessary to pull dash control only part way up for starting.

Hot water connection—is connected with suction end of pump (between radiator and pump). The connection on other side connects with water jacket of engine or upper water pipe. A shut off cock is provided for hot weather. See that these connections are made in such a way that water will be drained out of carburetor jacket when system is drained.

Attach a hot air stove to the exhaust pipe and connect to constant air elbow of carburetor by a flexible tube. **Connections:** are 5/16 inch outside diameter tubing for gasoline and water connections.

CHART NO. 85—Adjustment of Model "G & L" Rayfield Carburetor.

See "Specifications of Leading Cars" for users. Findeisen & Kropf Mfg. Co., Chicago, manufacturers. This concern manufactures another model called model "M." write for catalogue.

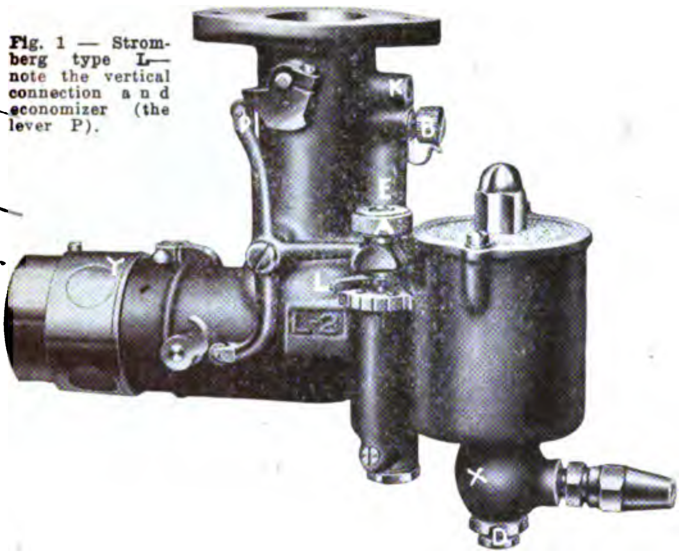


Fig. 1 — Stromberg type L—note the vertical connection and economizer (the lever P).

Stromberg Carburetor Models L and M.

The majority of Stromberg equipped cars are using **models** L, LB, M and MB, **which** are all called the **"plain tube carburetor,"** principle of **which** is explained on page 177.

The L and M models are the same carburetor, except, model L has an **"economizer"** action. The L & M are **made for vertical** connections **to intake** manifold. See figs. 1 and 2.

The LB and MB models are of the same principle as L & M, except they are made for **horizontal** connections to **intake** manifold. The **LB** has the **economizer** action, same as **L.**

The economizer action is as follows (fig. 1): The **high speed gasoline needle (A) is controlled by the nut (E), which rests on lever arm at** closed and open throttle. **With the throttle in ordinary driving positions—(15 to 40 miles per hour) the roller (P) drops into the cam notch, which permits the lever arm to drop free so that (A) descends to rest upon the economizer nut, thus lowering the needle into its orifice and partially cutting off the gasoline for these speeds. The amount of drop can be regulated by the pointer (L), which then acts as a special adjustment for the greatest possible economy.**

The object of the economizer is to automatically graduate the gasoline adjustment, which is controlled by the throttle. As throttle is opened the needle (A) is raised; as throttle is closed it lowers. The amount this needle (A) can be raised is regulated by (L).

To adjust the economizer (see fig. 1) the spark should be fully retarded and the throttle opened to a position which turns the engine at a speed corresponding to about 20 miles per hour (m.p.h.). The lever L should then be set one notch less than for the mixture on which the engine will run steadily. Under ordinary conditions this would be the third or fourth notch of (L) fig. 1. See also page 927.

*Adjustment of L & LB.

(1) Put economizer pointer in fourth notch.

(2) Open throttle to a position which will give about 20 miles per hour on a level road.

(3) Unscrew the high speed nut (A) to the left (counter-clockwise) until engine commences to fall away from too lean a mixture; then give richer mixture by turning the nut to the right, clockwise, notch by notch until a point is reached where the engine gives the best speed for that particular throttle opening.

(4) Then close throttle to idling position and adjust the idle screw (B), screwing inward. To the right, gives more gasoline; to the left, less.

(5) The dash control lever should be all the way down and the air horn cam plunger should clear the economizer lever so that this works freely as throttle is opened and closed.

Adjustment of M & MB.

(1) Open throttle about one-quarter of the way, which will give about 20 miles per hour on a pleasure car, (or one-third governor speed on a motor truck).

(2) Open idling screw (B) from its seat two turns, so that this cannot effect the high speed adjustment.

(3) Adjust high speed needle (A) to the leanest adjustment which will give the best engine speed for this throttle position. Inward for less and out for more gasoline.

(4) Close the throttle gradually and screw idling screw (B) in as necessary to give adjustment for low speed and idle. Screwing inward, right hand, gives more gasoline; outward gives less.

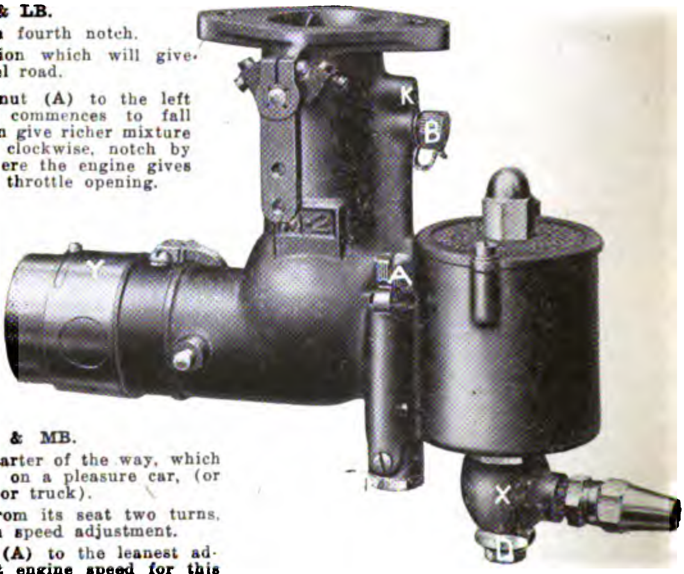


Fig. 2—Stromberg type M, without economizer. Used on small 4 cylinder engines for trucks, tractors, etc.

This "plain tube" principle is also known as the "Pitot" principle and is further explained on pages 177, 149 and 800.

CHART NO. 86—The Stromberg "Plain Tube Carburetor" L & M. ***Adjust only when engine is warm.**

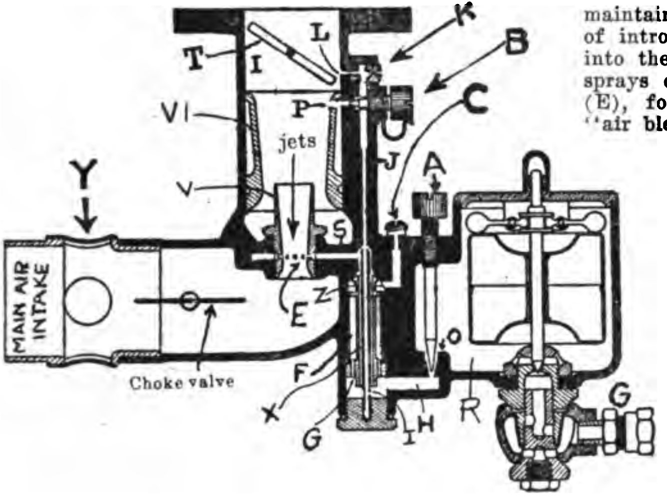
Note: all Stromberg carburetors are supplied with hot air attachments, similar to one described on page 159, fig. 1. Also a temperature regulator (Y) above, which principle is explained on page 159, fig. 2.

Principle of Stromberg ''Plain Tube'' Carburetor, (Model M).

This explanation also covers model L, LB and MB, except the economizer action, which is explained on page 176.

This carburetor is termed a ''plain tube'' type, because the whole air supply is taken through a single unobstructed channel of fixed size through the jet. Air valves, metering pins and dash pots have been dispensed with.

How the desired mixture can be maintained is answered in the principle of introducing a small amount of air into the gasoline jet at (C) before it sprays out into the main air passage (E), forming what is known as an ''air bled'' jet.



Action—the gasoline leaving float chamber (R) through (O and H), rises through a vertical channel (X) — not clearly shown, but around tube (J). Air taken in through (C), discharges into gasoline channel through small holes at bottom of passage (C), after breaking up into finely divided particles, the gasoline issues forth through a number of small holes or jets into the high velocity air stream of the small venturi (V). This gives a constant proportion of air to gasoline and atomizes the fuel completely.

The accelerating well; to accelerate or speed up an engine, requires enrichment of the mixture. Dash pots, metering pins, etc., have hertofore been used for this purpose, but here they are dispensed with. Concentric and communicating with passage (X), which conducts the gasoline to the jet, is formed a reserve chamber, or ''accelerating well'' (F). With engine idling or slowing down, this well fills with gasoline, and whenever the venturi suction is increased, by opening the throttle, the level of gasoline in this well (F) goes down, and the gasoline thus displaced passes through small hole (G) at bottom of well and joins the flow from (H), on up (X), out (S) into jet, thus more than doubling the normal rate of feed.

Idling—This is where tube (J) action comes in. Note that (J) is not mentioned up to this time. When throttle is closed, gasoline is drawn in through hole (I) at bottom of tube (J), mixed with air taken in at (P) and discharged through idling jet (L) with highest degree of atomization, due to the fact that a vacuum of more than 8 pounds exists above the throttle (T) when engine is idling and throttle closed.

As the throttle is opened from idle, and the engine speed increases, more gasoline is drawn through (O and H), and it begins to discharge into the small venturi (V), as well as though the jet at the edge of the throttle. Thus the gasoline is given alternative paths, so that it can follow the one leading to the greater suction.

The difference to be noted, between slow speed and high speed, is that the flow for **high speed** is not up the tube (J), but through passage (X), out (S) into jet. **For idling,** it is through tube (J), out (L) **and when opening throttle from idling,** out both.

There are two venturi tubes; a small one (V), and a large one (V1), which produces a very high air velocity. (see page 147 for explanation of venturi.)

Stromberg Model ''H.''

Is a different principle than L & M. It would be termed a compensating type carburetor.

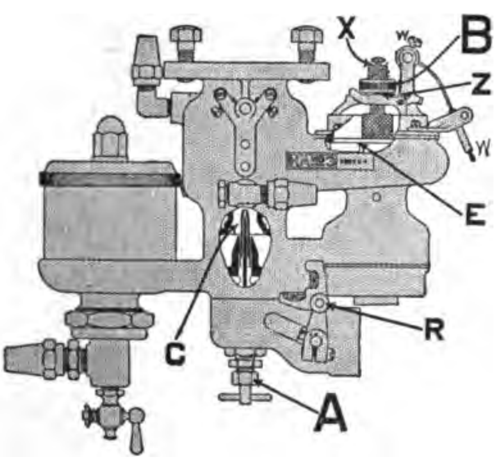
For low speeds the gasoline is taken from spray nozzle (C), in venturi tube, through which hot air passes. Regulation of amount of gasoline is by needle valve (A).

For high speeds, the nozzle in center of air valve, which is automatically regulated by opening of the air valve, thus supplying the necessary volume of gasoline for high speed. Adjustment for high speed is by (B), which controls the amount of flow of gasoline on high speed by regulating the time when the needle valve begins to open. Needle valve opens only when (B) comes in contact with (X). (B) is raised by throttle opening at high speed. There is usually about 1/32" clearance between B and X.

Low speed adjustment is controlled by the needle valve ''A.'' If too rich, as indicated by the engine ''rolling'' or ''loading,'' turn ''A'' up, thus admitting less gasoline and making the mixture leaner. If mixture is too lean, turn ''A'' down, thus admitting more gasoline and richer mixture.

High speed adjustment: Advance the spark, open the throttle. If mixture is too lean on high speed, screw ''B'' up until desired results are obtained. If mixture is too rich, screw ''B'' down.

—continued on page 178.



Stromberg Model H—with vertical connection.

CHART NO. 86A—Stromberg Carburetor. Explanation of the Model ''L & M,'' ''Plain Tube'' ''Pitot'' Principle of Carburetor and Model ''H,'' Compensating Type.

—Stromberg model "H"—continued.

Nozzle: Before changing a nozzle, check up closely on the ignition system, examine all manifold and valve head connections, **for air leaks,** as it is absolutely impossible to make a carburetor operate properly if the ignition is not in good condition or there are air leaks in the engine.

If, however, with the engine in normal condition it is necessary to turn needle valve "A" down more than two and a half turns, and still **engine will not idle,** it indicates that the **primary nozzle is too small** and that a larger one should be used.

If it is impossible to get enough gas on high speed except when nut "B" is so high that there is no clearance at "X" on idle, a **higher number needle** should be used.

If too much gas on high speed when nut "B" is turned down as far as it will go, a **lower number needle** should be used.

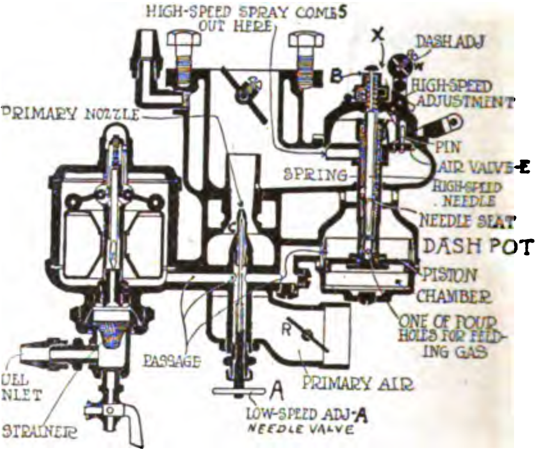
To change the primary nozzle, take out the **needle** valve "A" and remove nozzle with a **regular screw** driver. To remove taper valve on high **speed, pull** up **steering** post control, unscrew nut "B" **all the** way and lift valve out. This valve and nut "B" are assembled together and should be **ordered in** that way. Do not attempt to **take these apart or** to change the taper.

Never change nozzle more than one size at a time. **The nozzle opening gets smaller as the** number **gets larger;** thus—a No. 59 is **smaller** than a No. 58.

High speed needle valves deliver more gas **as the** number gets larger; thus—a number 7 **will give** more gas than number 6.

Always install carburetor with the float chamber towards the radiator.

This carburetor was used on 1917 Marmon.



Stromberg model HA—sectional view.

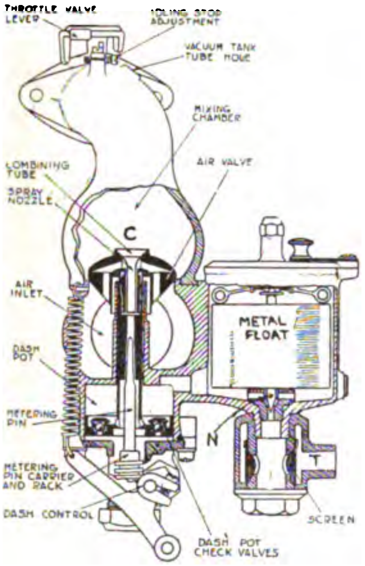


Fig. 4—There is only one adjustment and that is the metering pin, which is interconnected with the throttle. Ordinarily the metering pin should be two-thirds the way through.

Stewart Carburetor (on the Dodge).

On the Dodge the carburetor (figs. 4, 3) is on left side of **engine,** and is fed from a Stewart vacuum tank. The carburetor is **supplied with a** hot air attachment which draws air from **around** exhaust manifold to air inlet.

Principle: (fig. 3). The automatic metering **valve (A) rests** on the valve seat **(B)** when the engine is not running. **As the** engine begins to rotate the suction of the pistons raises the valve (A) from the seat drawing in air around it (R to B) as indicated by arrows. The suction also draws gasoline up within the valve stem as indicated by arrow from (R) which mixes with the incoming air in the chamber (C).

The one adjustment of the Stewart is that of proportioning the volume of gasoline to the air admitted. The air being **always a** fixed factor it is only necessary to adjust or regulate the **volume** of gasoline admitted which is controlled by means of the **tapered** metering pin (D).

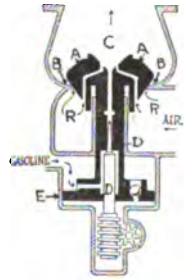
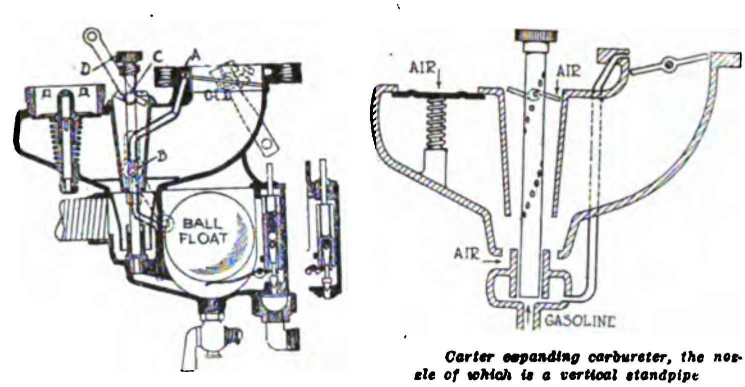


Fig. 3—How the metering pin D varies the mixture in the Stewart. Air passes through the passages R around the nozzle

This adjustment is made when the engine is running at idling speed. By turning the adjusting screw (on "dash control," see lower part **fig. 4**). either to the right or left, raises or lowers the position of the tapered **metering** pin, thereby allowing an increased or decreased supply of gasoline to be **drawn** up into the mixing chamber. When the proper proportion has been **determined** at slow speed, it will be seen that as the speed of the engine increases, **the** automatic metering valve **(A)** will rise higher from the seat **(B)** and **away** from the tapered metering pin **(D)** which will allow a greater supply of **both** gasoline and air, in exactly the same proportion, be admitted to the **cylinders.**

On the Dodge, fig. 4, the tapered metering pin is subject to control within fixed limits by means of the "dash control" ratchet, (see lower part of **fig. 4** for connection), for the purpose of obtaining a rich mixture for **starting. Should there be any reason for changing the fixed adjustment** of the **tapering** metering pin (D), it can be done by turning the stop screw adjustment on **the** "dash control," (see lower part of fig. 4). Turning it to the **right lowers** the positon of metering pin and allows **more** gasoline to be **admitted to the** spray nozzle—enriching the mixture. Turning it to the **left** raises pin **and decreases** supply. The **throttle valve** is in top of carburetor, (see fig. 4.)

CHART NO. 87—Stromberg Model "H"—Continued. **Stewart Carburetor on the Dodge Car.** (see page 162, Address of Carburetor Manufacturers.)



Carter expanding carburetor, the nozzle of which is a vertical standpipe

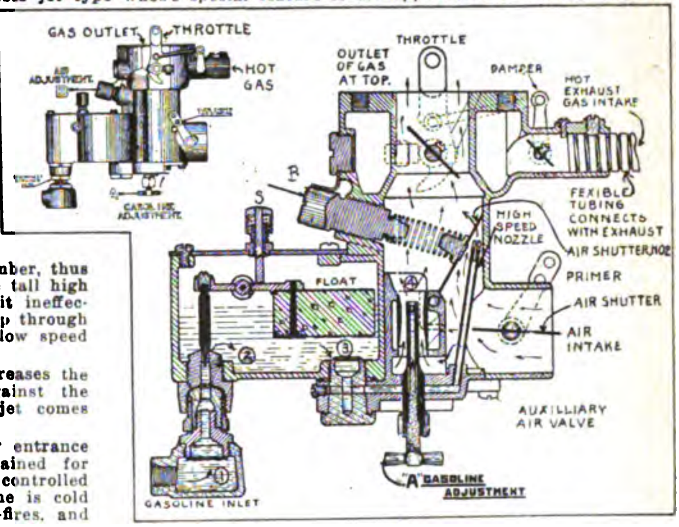
The Carter

can scarcely be called a multiple-jet, yet it is a typical expanding design. The illustration shows why it is included in this classification in that its nozzle is a vertical standpipe in the walls of which are drilled various holes in the form of an ascending spiral and out of each hole the gasoline issues. At low speeds, when the gasoline is drawn to only a moderate height in this standpipe, the fuel issues from but few of the lower holes. As the gasoline rises higher in the standpipe at intermediate speeds it issues from more of the openings; and when it rises still higher at high speeds yet more of the openings are brought into operation. The main air opening is in a vertical tube surrounding this standpipe so that the inrushing air passes along the pipe excepting at the lower end. There is an auxiliary air valve. The pipe or multiple jet tube B can be unscrewed by the kurled head D. Heated air can be drawn in at the side.

At C—air enters; the amount is controlled by the little throttle shown. Still more air can pass into carburetor from the air valve on the left side, this supplementary supply passing upwards after mixing with the warm air.

The Marvel Carburetor—(used on Buick).

The Marvel model E is a double jet type whose special feature is the application of exhaust heat to a jacket surrounding the throttle chamber and venturi tube, amount of heat being automatically controlled by the throttle opening. Outside the float mechanism this carburetor has but one moving part, the auxiliary air valve.



Two jets are used, a primary low speed jet and a secondary high speed jet which is brought into action by the opening of the auxiliary air valve.

When the engine is idling the hinged auxiliary air valve rides on its seat against bore of mixing chamber, thus closing off the air passage past the tall high speed jet in this part, rendering it ineffective. At this time the air passes up through the small venturi surrounding the low speed jet.

As the suction of the engine increases the auxiliary air valve is opened against the spring pressure, and the second jet comes into action.

A choker valve in the main air entrance allows a rich mixture to be obtained for starting. This device may be controlled from the dash so that when engine is cold it may be closed to prevent back-fires, and gradually opened up as engine warms up.

The feature of this carburetor previously mentioned is the exhaust heated jacket. The heat is controlled by a damper connected to the throttle lever, which damper can be set to give any degree of heat desired. This is of particular importance as the quality of gasoline is yearly becoming heavier and heavier. This heat damper therefore can be set to admit sufficient heat to secure good vaporization of such heavy fuel on low throttle, and then as throttle is opened the heat is automatically cut off, thus insuring maximum power at the higher speeds where heat is not necessary to good carburetion.

By such an application of heat the entering air is not preheated and this naturally results in greater thermal efficiency and power due to a maximum cylinder filling at each stroke of pistons.

Adjustment; start by turning needle valve "A" to the right until it is completely closed. Then adjust the air adjustment "B" until the end of the screw is even with the end of the ratchet set spring above it.

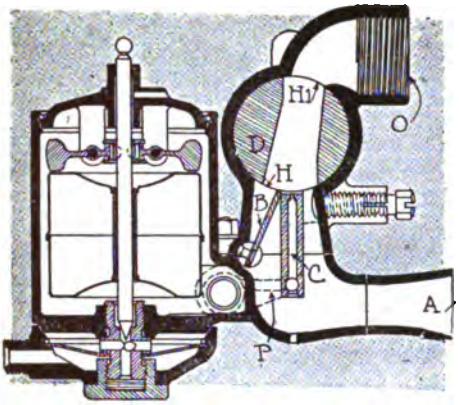
Next open "A" (gasoline needle) one turn, start the engine as usual, using the strangler button (S) to get a rich mixture at first. Allow engine to settle and warm up; then gradually cut down on "A," until engine runs smoothly.

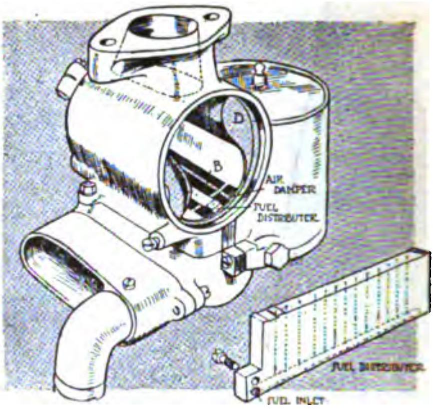
Next turn air screw "B" to the left, a little at a time, until engine begins to slow down. This indicates that the air valve spring is too loose. Turn it back to the right just enough to make the engine run well.

To test the adjustment, advance the spark and open the throttle quickly, the engine should "take hold" instantly and speed up at once. If it misses or, "pops back" in the carburetor, open needle valve "A" slightly turning to the left. If this does not give results, the air screw "B" may be tightened a little by turning slightly to the right. It should be borne in mind, that the air valve should be carried as loosely as possible, and that the adjustment for "pick-up" may be obtained by carrying more gas with needle valve "A" rather than to tighten up the air valve too much.

The best possible adjustment is secured when air adjustment "B" is turned as far as possible to the left and needle valve "A" to the right, providing the engine runs smoothly and picks up quickly when the throttle is open. The speed of the engine is governed by the small set screw in the throttle stop. If the engine runs too fast, turn screw to the left, if too slow, turn screw to the right.

CHART NO. 88—The Carter Carburetor. The Marvel— (see addresses of manufacturers on page 162





The Master Carbureter is a Concentric Float Type with a rotary throttle and horizontal fuel distributer extending across the air passage.

Referring to the Sectional View, the fuel distributer extending across the air passage is shown at C. This has a number of small holes drilled along its length, and the lower opening H in the rotary throttle D is so shaped as to uncover more and more of these holes as the throttle is opened . At the same time, due to a similar opening H in the upper surface of D, an increasing amount of gas is admitted through the intake O. Thus the fuel supply is mechanically apportioned in accordance with the throttle opening.

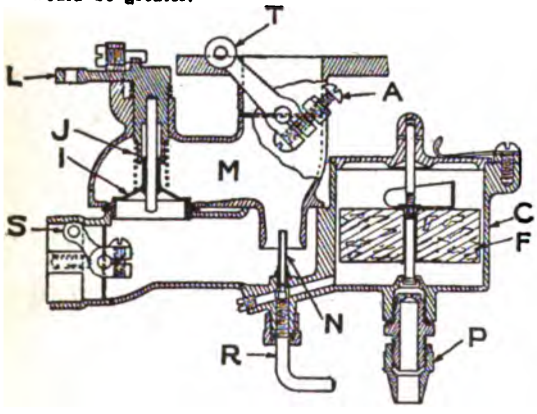
When the Throttle is Wide Open there are no restricted passages.

The Air Enters through the Intake A and mixes with the fuel issuing from the small holes, and passes on to the engine through the openings H and H'.

The Gasoline gets to the Distributer through the Passage P from the float chamber. A common supply tube running along the lower part of the distributer takes care of each individual distributer tube.

One Jet for Idling. When the throttle is closed, there is still one distributer hole uncovered which admits sufficient fuel for slow-speed or idling.

To Regulate the Air Supply and thus control the mixture, the air damper B is placed in the air passage. This is simply a flat piece of metal arranged to swing about its base so as to shut off any part of the air. As shown, it is set for a rich mixture, whereas, if partly open, the proportion of air would be greater.



THE MAYER CARBURETOR (Example of Model used on the Saxon.)

Carburetor Action: The float chamber maintains a constant level or supply of gasoline for the motor. Gasoline flows from the feed pipe through an intake plug (P),thence through the float valve and into the float chamber (C). A cork float (F) raises or lowers the float valve, thus regulating the incoming flow of gasoline in proportion to the supply in the float chamber.

After leaving the float chamber the gasoline passes through a nozzle (N) from which it is sprayed in a fine stream into the mixing chamber. The quantity of gasoline passing through the nozzle is regulated by the "needle valve" (R).

The suction created by the downward motion of the motor pistons draws air into the mixing chamber (M) through the primary and auxiliary air inlets. This air flows into the mixing chamber around the nozzle and picks up the gasoline which leaves the nozzle in the form of a spray. Thus the action of the mixing chamber is not unlike that of an ordinary atomizer in which the air, forced from the rubber bulb, picks up a certain amount of the liquid in the bottle and sprays it out in the form of a fine vapor.

At the front end of the carburetor is the auxiliary air inlet (I). At low speeds, when only a small amount of air is being drawn through the carburetor, the spring (J) holds this valve almost shut. As the speed increases and more air is needed, the suction draws the valve further open, admitting more air and automatically producing the correct mixture for all motor speeds.

When Adjustments are Necessary, observe the following instructions:

Adjust float (F), which is right when about 9/16 in. from top of float chamber, or when in about the third groove on float valve stem.

Slow Speed Idling: Throttle valve (T) should be adjusted at (A), to get proper speed for idling. The needle valve (R) is adjusted only to get proper mixture at low speed. The auxiliary air adjustment (L) takes care of high speed.

High Speed Adjustment: With the needle valve adjusted for proper mixture at low speed, the only adjustment required for high speed may be made from the dash, by means of dash adjustment, which operates cam lever (L). For less air, pull the dash adjustment out. It is advisable to use as much air as possible, as this gives best economy.

Easy Starting: To start the motor, close starting valve (S), which is operated by rod running to front of radiator, crank motor, and open starting valve immediately. In starting, during cold weather. with the motor cold, the air can be cut down to suit conditions, then, after motor is warmed up, the air may be readjusted.

If the weather is cold or extremely humid, turn the needle valve (R) at bottom of carburetor to the left for more gas, while the motor is running, until it fires evenly under load or while the car is in motion. Too rich a mixture will be distinguishable by black smoke from the exhaust. Too light a mixture will cause uneven firing of the motor.

If the weather is hot or extremely dry, readjust needle valve, turning to right for less gas.

HART NO. 89—The Master Carburetor. The Mayer.
Master Carburetor Co., Detroit; Mayer Carburetor Co., Buffalo, N. Y.

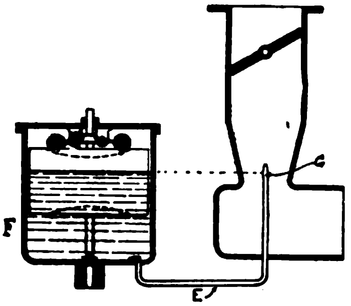


Fig. 1. A simple type of carburetor. Jet (G), fed from float chamber.

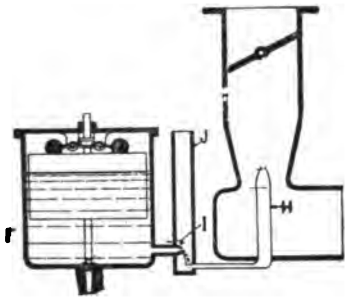


Fig. 2. Spray nozzle (H), receives gasoline from well (J), instead of float chamber.

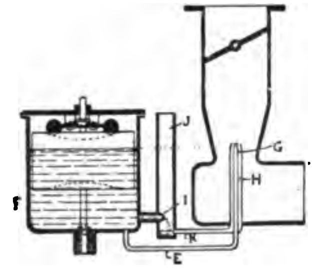


Fig. 3. A combination of 1 and 2.

Principle of the Zenith Carburetor.

We shall first consider a simple type of carburetor or mixing valve. This consists of a single jet (G), placed in the path of the incoming air, and fed from the usual float chamber (F), see fig. 1.

As the speed of the engine increases, the flow of the air increases, but the flow of gasoline from the jet increases faster, causing the mixture to become richer and richer. The mixture is practically constant only between narrow limits and at very high speed.

A second type of carburetor (fig. 2), is shown in which the spray nozzle receives its gasoline from the well (J).

The gasoline in the well is fed by gravity only through compensating jet (I), and is not affected by the suction, as the well is open to atmospheric pressure. The flow of gasoline is therefore constant at all engine speeds, while the flow of air increases with the engine speeds, the mixture also becomes poorer and poorer as the speed increases.

It will readily be seen that the second type produces the opposite effect from the first, while a combination of the two is shown in fig. 3, will result in a constant mixture, when jets are properly chosen.

This construction, further illustrated in fig. 4, admits of the addition of the priming tube (J) extending into the secondary well (P) and opening at the point (U) of the closing butterfly (T). With the butterfly partially open, the suction at this point (U) is powerful and draws the well full of gasoline into the cylinders, effectively priming the engine. Also by the introduction of this secondary well, which measures the gasoline used in running idle, a perfect mixture is obtained at very low engine speeds.

The level of the gasoline in the float chamber is set at the factory and need not be changed, but in case it does, the gasoline level is as shown on page 168.

Causes and Remedy of Troubles.

The matter in this page as well as the adjustments on page 182, refer to all types of Zenith Carburetors.

If engine does not slow down or idle: If engine "lopes," that is speeding up and slowing down as if fitted with governor; evidently too much gasoline—(1st) adjust air screw (O). (2nd) look for air leaks at manifold and other joints. See that jets are tight on seat. (3rd) water accumulation in the passages; remove plugs under carburetor and clean (I) and (G).

If engine does not pull properly going up hill: (1st) engine cold, insufficiently heated. (2nd) mixture too lean or too rich (irregular running results in latter case) try a larger and smaller compensating jet (I), using the one which gives best results. Also jet (G) and corresponding size of choke tube.

If the car does not attain its proper speed: (1st) mixture too lean; try adjusting slow speed (O). If chronic, try larger main jet (G). (2nd) mixture too rich, try regulating air intake at Z (figure 2, page 159). If chronic try a smaller size main jet (G).

When trying a new jet, the choke tube (X) must also be changed. Choke can be removed from upper part of barrel by removing screw (X1) and throttle valve. If stuck, remove cap and jet at lower part of carburetor and use a brass rod to drive it out.

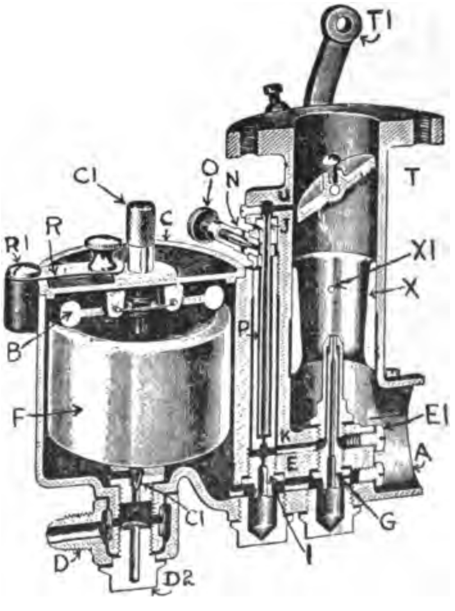


Fig. 4. Zenith carburetor for 4 or 6 cylinder engine.

CHART NO. 90—The Zenith Carburetor: Principle. See page 159 for the Temperature Regulator used with this carburetor. Also refer to index for "Specifications of Leading Cars" fo users. (Zenith Carburetor Co., Detroit, Mich.)

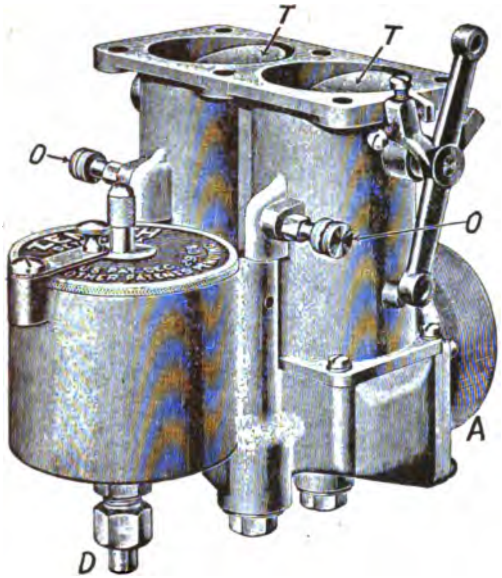


Figure 5. Zenith "Duplex" Carburetor for "V" type engine.

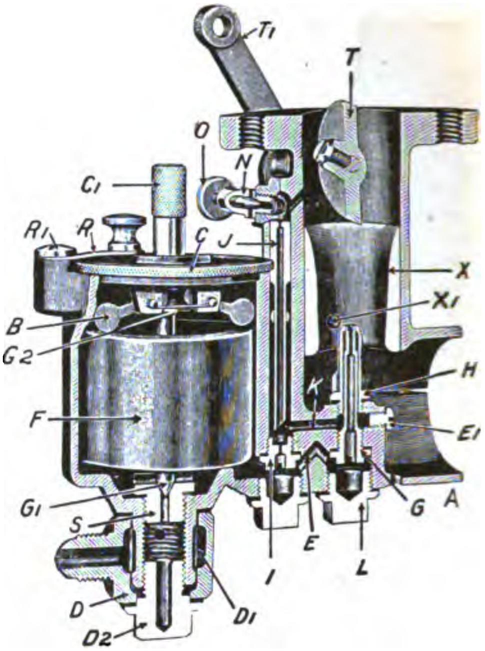


Figure 6. Sectional view of Zenith Duplex.

A—Main air intake, connected by flexible tubing to take air from around the hot exhaust pipe. C—float cover. C1—Needle valve cap. By unscrewing this the float can be operated for priming if necessary. D—Connects to gasoline supply.
D1—Filter screen.
D2—To drain.
E —High speed gas opening.
E1—Main jet set screw.
F —Float (metal).
G —Main jet.
G2—Needle valve collar.
H —Cap jet.
I —Compensator.
J —Priming plug in idling well.
K —Low speed gas opening.
L—Lower plug.
N—Seat of slow speed adjustment screws.
O—Slow speed adjustment screws.
R—Spring to hold float cover.
S—Needle valve seat.
T—Butterfly throttle valve which is operated by T1, which is connected by throttle rod to accelerator or hand throttle lever on steering wheel. The opening of T, when closed for idling, is regulated by the stop and two set screws shown to the side of T1.
T1—Lever operating throttle butterfly valve.
X—Choke tube.
X1—Screw holding choke tube in place.

Adjustments of the Zenith: There are but two adjustments on the Zenith. These adjustments are provided to properly "idle" the engine. With the average carburetor, if maximum speed is desired proper idling at slow speed is sacrificed or vice versa. By means of admitting more or less air, however, through the small slow speed adjusting screws (O) the Zenith carburetor will idle without "choking" and "loping" and yet, the maximum speed can be obtained—providing, of course, the main jet, compensator and choke tube are the proper size.

By referring to the illustration fig. 6 it will be observed that a small amount of air is admitted over and above the mixture through the plug (J) that is fed from the idling well. After the engine is speeded up the mixture is drawn through the main jet.

There are three parts which must be of the correct size. The choke tube (X), main jet (G), compensator (I). The size is determined by the manufacturer, according to the type of engine; four, six or eight cylinder, bore and stroke. After once being fitted to carburetor then there are no other adjustments except the slow speed valve (O) as mentioned above.

If the choke tube is too large the pick-up will be defective and can not be bettered by the use of a larger compensator. Slow speed running will not be very smooth.

If the choke tube is too small. The effect of a small choke is to prevent the engine from taking a full charge with the throttle opened fully. The pick-up will be very good, but it will not be possible to get all the speed of which the car is capable.

If the main jet is too large. At high speed on a level road it will give the usual indications of a rich mixture; irregular running, characteristic smell from the exhaust, firing in the muffler, sooting up at the spark plugs, low mileage. The influence of the main jet is mostly felt at high speeds.

If the main jet is too small. The mixture will be too lean at high speed and the car will not attain its maximum. There may be back firing at high speed, but this is not probable, especially if the choke and main jet are according to the factory setting. This back-firing is more often due to large air leaks in the intake or valves or to defect in the gasoline line.

The compensator (I): From the explanation of the Zenith principle given on page 181, it is readily noted that the influence of the compensator is most marked at low speeds. The compensator size is best tried out on a hill, as regular as possible and as long as possible, and of such a slope that the engine will labor rather hard to make it on high gear. A long, even, hard pull of this sort taxes the efficiency of the compensator to the utmost, and will indicate readily the correctness of its adjustment.

If the compensator is too large. Too rich a mixture on a hard pull. It will give the same indication as for rich mixture at high speed on the level.

If the compensator is too small. Too lean a mixture. Liable to miss and give a jerky action in the car, on a hard pull.

Remark: When trying out or fitting new jets, etc., tests should be made systematically, first starting the main jet, then the compensator, then the choke. Bear in mind that when the choke is increased the main jet should be increased. Water in gasoline will sometimes lodge in tube (J) and prevent proper idling. Remove and clean. This is a common trouble unless a strainer is used. **Temperature regulator type** used on the Zenith is shown on page 159, fig. 2.

CHART NO. 91—The Zenith "Duplex" Carburetor (vertical type) **as used on V-type Automobile** and Airplane Engines.

The Hudson Carburetor

Is illustrated below. The carburetor is of the "metering pin" type, also called "measuring" pin. A, fig. 1, is the measuring pin, which is controlled by a small lever connected with the "gasoline feed regulator lever." This lever is connected with a lever on the dash which "measures out" the gasoline to be fed. A study of fig. 1, will make this clear.

The air entering carburetor is also controlled by "air lever" on dash. Note in fig. 1, the body of carburetor is not shown, but is illustrated separately in figs. 3 and 2.

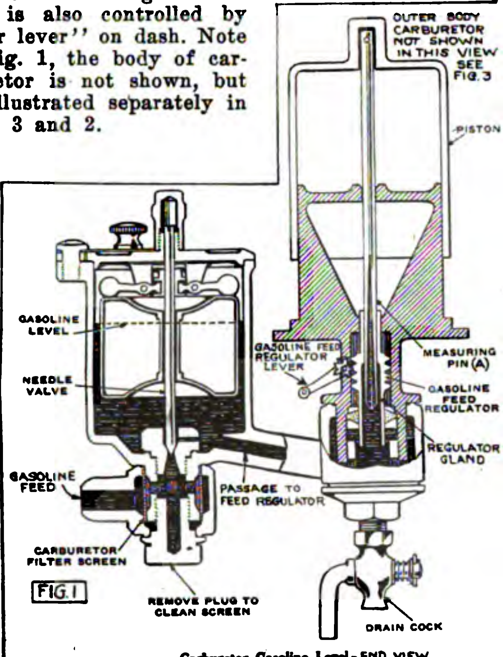

OUTER BODY CARBURETOR NOT SHOWN IN THIS VIEW SEE FIG. 3
PISTON
GASOLINE LEVEL
NEEDLE VALVE
GASOLINE FEED REGULATOR LEVER
MEASURING PIN (A)
GASOLINE FEED REGULATOR
REGULATOR GLAND
GASOLINE FEED
PASSAGE TO FEED REGULATOR
CARBURETOR FILTER SCREEN
REMOVE PLUG TO CLEAN SCREEN
DRAIN COCK

FIG. 1

Carburetor Gasoline Level - END VIEW

Instructions for Assembling Measuring Pin and Piston

IMPORTANT

WHEN ASSEMBLING METERING PIN AND ALSO THE AIR BELL TO THE THROTTLE BODY BE SURE THE ARROW ON THE BELL POINTS IN THE SAME DIRECTION AS THE OPEN END OF THE V GROOVE, VIZ., ⊙←◄ AND THAT ARROW ON BELL ALSO POINTS IN SAME DIRECTION AS ARROW IN THROTTLE BODY.

THESE ARE IMPORTANT FOR CARBURETOR TO FUNCTION PROPERLY

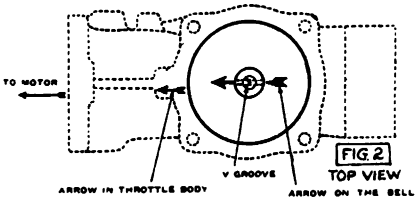


FIG. 2 TOP VIEW

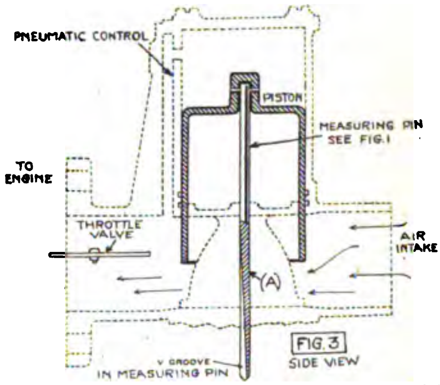
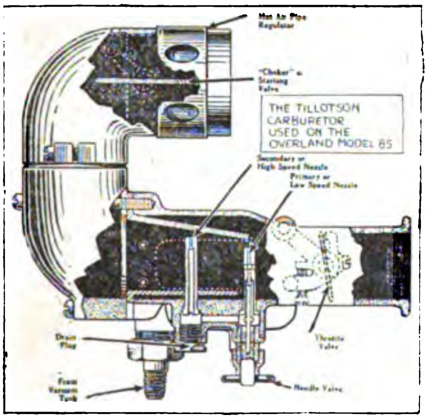
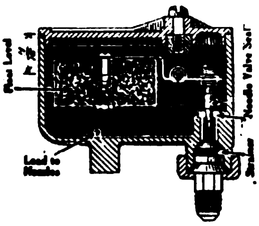


FIG. 3 SIDE VIEW


Hot Air Pipe Regulator
"Choker" or Starting Valve
THE TILLOTSON CARBURETOR USED ON THE OVERLAND MODEL 85
Secondary or High Speed Nozzle
Primary or Low Speed Nozzle
Drain Plug
Throttle Valve
From Vacuum Tank
Needle Valve



Float mechanism of the Tillotson carburetor, used on the Overland: Note level of gasoline.

Tillotson Carburetor

Used on the Overland engine is illustrated. may be termed a double jet, variable venturi ca buretor.

A uniform partial vacuum is maintained at t fuel nozzle by two flexible reeds, which are mount in a cage, so designed that the maximum openi gives the required volume for maximum speed.

When the reeds (fig. 2) are closed they cause t highest possible vacuum at slower engine spee

The reeds open and close according to the speed of engine. These reeds are so placed that as they move they form a virtual variable venturi. A secondary nozzle comes into operation at higher speeds and is not in use at the lower speeds.

Adjustment; there is but one, which is the needle valve.

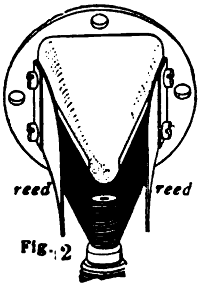


Fig. 2

Position of reeds a wide open throttl High engine speed

CHART NO. 91B—The Hudson Carburetor—metering pin type. **The Overland Carburetor** lotson).

FIG 1

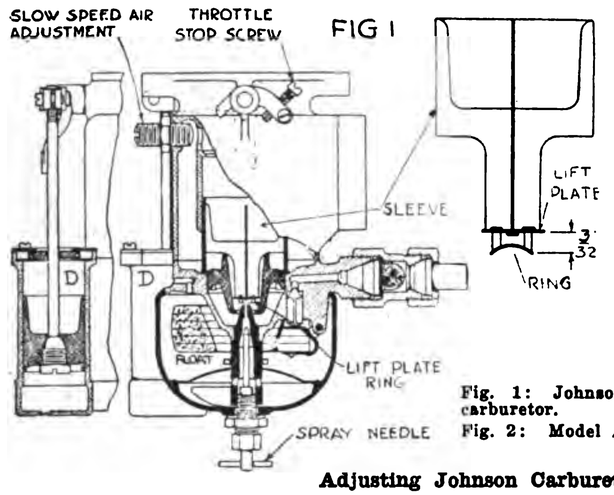


FIG 2

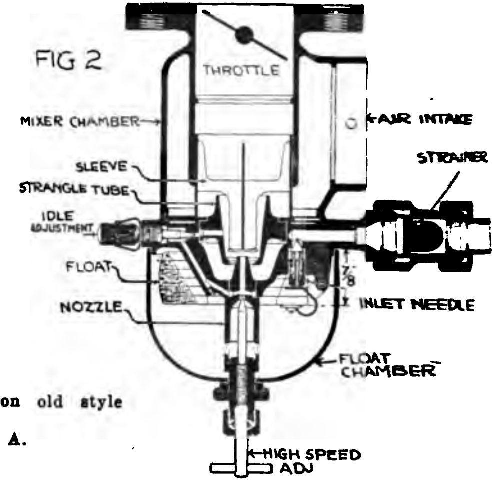


Fig. 1: Johnson old style carburetor.
Fig. 2: Model A.

Adjusting Johnson Carburetor (old style).

Indications of adjustment: **(A)**—lean mixture; **(B)**—engine difficult to start; **(C)**—"popping-back" on quickly opening throttle; **(D)**—engine knocks when throttle is opened quickly; **(E)**—engine will not idle.

Many mechanics can adjust this carburetor for high speeds but sometimes find difficulty in adjusting for low speeds or idling.

The correct procedure of adjustment is as follows:

(1)—retard spark.

(2)—close the slow speed air adjustment screw (fig. 1).

(3)—warm engine.

(4)—see that the intake pipe manifold where it connects to carburetor flange does not leak air. Sometimes a water jacketed intake manifold will become "air-locked" and water will not circulate, depriving it of heat. Open "plug," as per fig. 1A, page 157.

(5)—accelerate engine by opening and closing throttle rapidly. If mixture is too **rich**, acceleration will be sluggish; if too **lean**, it will "pop-back" considerably. The spray needle adjustment should be set between these two points.

(6)—retard the spark and close the hand throttle. Adjust the throttle stop screw until the engine runs very slowly regardless of whether it operates evenly or not.

(7)—open the slow speed air adjustment until the engine idles evenly if possible. If it runs too fast close down the throttle stop screw. The adjustments on the stop screw and the low speed screw should be made simultaneously.

(8)—it may be found that the low speed air adjustment cannot be opened at all. In this case the low speed mixture is too lean. Possibly the low speed air adjustment can be opened more than 3½ turns, when the mixture is too rich. Do not touch the spray needle setting, but proceed as follows:

(9)—disassemble the carburetor. A small ring, shown (fig. 1) is attached by two lugs to what is known as the lift plate. This ring is somewhat curved, and if the slow speed air adjustment can be opened more than 3½ turns without obtaining good idling, the curve is excessive and the ring should be slightly flattened.

(10)—if on the other hand the air adjustment cannot be opened, the ring is too flat and should be slightly curved. The standard setting is 3/32 in. from the edge of the ring to the lift plate to which it is attached.

Adjusting (Model A).

(1)—turn both idle screw and high speed needle (fig. 2), to their seats, and set the throttle stop approximately the correct position for closed throttle.

(2)—open the high speed needle 1½ turns. This permits the engine to be started. Warm the engine up by running a few minutes.

(3)—place spark lever in full retard position, and open the throttle until the engine turns at a speed equivalent to about 20 to 25 miles per hour.

(4)—turn high speed spray needle to the right until the engine speed decreases.

(5)—then turn the spray needle to the left until the engine speed increases and then decreases from a rich mixture.

(6)—turn again to the right to a point midway between the extremes. This is the correct mixture and will give the best results for all throttle positions.

(7)—Adjust the throttle stop screw to the desired idling position.

(8)—**if uneven firing occurs** correct either by unscrewing the idling jet to enrich the mixture or screwing up the idling jet to give a leaner mixture. The average setting is ½ turn from the seat. This adjustment must be made with the spark and throttle levers fully retarded.

The float should set evenly all around, the bottom being ⅞ in. from the float chamber seat as shown in fig. 2.

Principle of Johnson Carburetor.

The Johnson is a "**gravity air valve type,**" with a single concentric jet, in which air valve is made up of a sleeve rising and falling by suction and gravity in cylindrical passage above jet.

There are three **stages of vacuum**; one is the space between the throttle and strangle tube, the second, in the strangle tube itself, and the third, in the space below the plate on the bottom of the air valve sleeve. By removing the location of the idling adjustment (in fig. 1) the flow of gasoline for this purpose has been brought into a zone of greater vacuum and hence better idling.

NO. 92—Johnson Carburetor. See "Specifications of Leading Cars" for users, page 543.

INSTRUCTION No. 14.

*COOLING: Water Cooling. Circulating Pumps. Radiators. Fan. Water Thermostat. Radiator Damper. Air Cooling. Cause of Trouble in the Circulating System. Cleaning Radiator. Stopping Leaks. Non-Freezing Solutions. Heating a Car.

Water Cooling.

If no provision is made for cooling the cylinder of a gasoline engine, the intense heat of the explosions would heat it to a point that would cause the lubricating oil to burn, and become useless. At the same time, the cylinder must not be kept too cool, for that would prevent development of full power; the cylinder must therefore be permitted to get as hot as is possible without burning the lubricating oil. About 170 degrees Fahr. or below the boiling point, appears to give the best results—see page 188, fig. 9.

The cylinder may be cooled either by water or air, and while the greater number of engines are water cooled, air cooling, however, has been developed to a point where successful results are attained.

The water cooling system consists of jackets (see fig. 6, page 188), around the part of the cylinder that is to be cooled, through which water may flow; a radiator or cooler for cooling the heated water; and some method of keeping the water in circulation, together with the necessary connections (see charts 94 and 95). **The jackets** are usually cast in one piece with the cylinder, although in some cases they were formerly made by forming sheet copper around the cylinder to form passages through which the water would circulate. When heated, the water passes to the radiator, where the rush of air to which it is exposed absorbs the heat, cooling the water.

To maintain the cylinders at a workable temperature, a quantity of water is carried in a supply tank or radiator, from which it is caused to circulate continuously through the jacket of the engine cylinder by a small pump driven direct from one of the cam shafts or by the thermo-syphon principle. The heated water from the cylinder returns back to the tank on radiator and then passes through a series of thin copper tubes. The object is to dissipate as much as possible, the heat absorbed by the water by exposing it to a large cooling surface of metal.

The radiator system is always fixed in the forward part of the car, to obtain the full benefit of the draught of air. The same water is used over and over again so that it is only necessary to replace the loss caused by evaporation and leakage.

It is usual with radiator systems to have a rotary fan to assist in inducing a draught of cold air through the radiators and accelerating the cooling when the car is moving slowly, as in hill-climbing or slow running in traffic. The fan is driven from the engine shaft by a belt or gear and fixed back of the radiator. (Fig. 6, chart 95.) The alternative method, which avoids the use of a separate fan, is provided by fan-vaned arms in the fly wheel. (See fig. 3, chart 94.)

The two systems of circulation are the "thermo-syphon" system and the "force" system.**

Thermo-Syphon Water Circulation System.

The thermo-syphon circulates the water, because when water is heated, it rises. The connections are the same as for the force system, except there is no pump, and the connection from the water jacket outlet to the top of the radiator slants upward. It is more necessary to have clear passages for the thermo-syphon system than for the force system, because the pump, in the force system, will force the water past an obstruction that would stop the flow of water that moves only because of its heat.

Height of radiator—Thermo-Syphon system—must be higher and lower than the extreme top and bottom of the water jacket. (See fig. 6, chart 95.)

Height of water—Thermo-Syphon system—to properly circulate, water should be kept at level above top inlet of radiator. Below this point circulation ceases and water boils.

Force Water Circulation System.

In the force system, the engine drives a pump which keeps the water in constant circulation, as shown in fig. 4, chart 94 and fig. 7, chart 95. The pump forces the water from bottom of radiator to the inlet at the bottom of the water jacket, through which it flows to the outlet at the top, whence it goes to the top of the radiator, flows through the radiator to the bottom. As it passes through the radiator tubes it is cooled. After passing through in this manner it is again drawn through the pump.

---

*By referring to page 543, "Specifications of Leading Cars" the cooling systems of leading cars, is given.

**Lower priced cars show a tendency to use the thermo-syphon system whereas higher priced cars the pump or forced circulation.

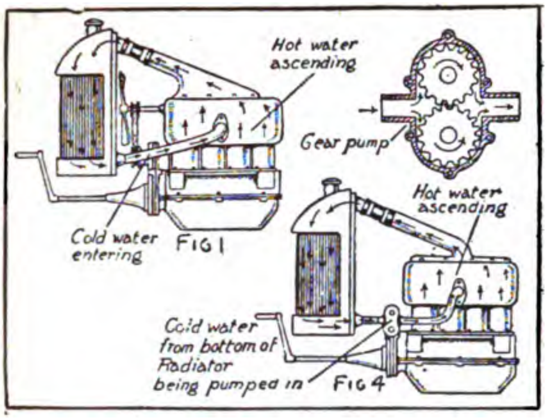


Fig. 1—Thermo-Syphon principle of water circulation.

Fig. 4—Forced or Pump principle of water circulation.

The gear type pump is shown at the top, right hand corner.

Water Cooling Systems.

Fig. 1—Thermo-Syphon Circulating Water Cooling System. This system does not require a force pump to circulate the water. The water enters the cylinder jacket at bottom. Upon becoming heated by the explosions going on within the engine the water rises to the top, entering the pipe and passing into the radiator at top where it is brought into contact with a large cooling surface, in the shape of the radiator. On being cooled and thereby becoming heavier, the water sinks again to the bottom of the cooling system, to enter the cylinders once more and to repeat its circulation. The cooling action is further increased by a belt-driven fan which draws air through the radiator spaces.

Fig. 2—A Thermo-Syphon system in which independent pipes are taken from each pair of cylinders, the outlet pipes joining at the upper or tank part of the radiator. Cylinders in this instance are cast in pairs.

Where cylinders are cast en-bloc, one water inlet and one water outlet pipe will suffice, as in Fig. 1.

Fig. 3—Simple Thermo-Syphon Circulation. (Renault system.) **Pump dispensed with. The arms of the fly wheel are designed to act as fan blades;** a separate fan is unnecessary, but the underpart of the engine must be carefully screened in.

Fig. 4—Forced Circulation Water Cooling System. A water circulating pump is used with this system to force the circulation of water through the water jacket and radiator. A fan is also used, but not shown, which is driven by a gear from a cam shaft. The fan draws air through the radiator tubes. Fresh air passing through the tubes tends to keep the water cool. At the point "G" fig. 7, chart 95, gaskets are used to make water tight joints with the water pipes.

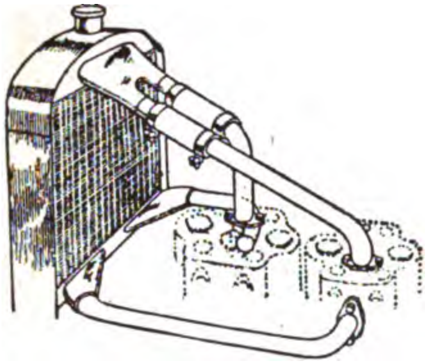


Fig. 2.

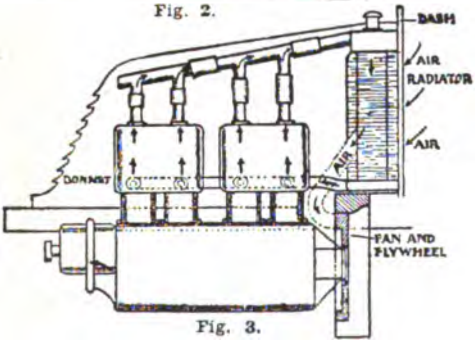


Fig. 3.

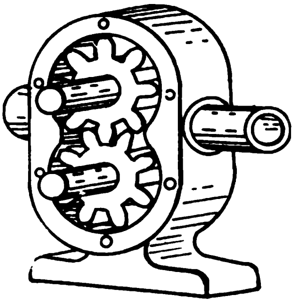


Fig. 5—A gear type of circulating pump consists of two small gears with large teeth, the two being in mesh, and placed in a casing that fits as snugly as possible. The water enters at one side where the teeth separate and is carried around to the opposite side in the spaces between the teeth where it escapes through an outlet. This is the type in general use.

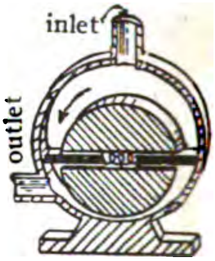


Fig. 7—The rotary type of circulating pump consists of a ring-shaped casing, within which a disc revolves, the disc being "eccentric," or to one side of the center of the casing. Through a slot across the disc are two arms their ends being pressed against the casing by a spring. As the disc revolves, the water is forced from the inlet to the outlet by the arms.

Fig. 9—This illustration shows how the fan (see fig. 6, chart 95) **draws air in through the cores in the radiator to keep the water cooled.** This demonstrates clearly the function of the fan, and shows how futile is its attempt to cool the radiator when the winter cover is fully closed. There is no cooling action to the fan unless the front of the radiator is at least partially exposed.

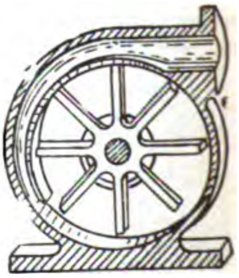


Fig. 6.—The centrifugal pump acts on the principle of an air blower, and has blades projecting from a hub, which revolves at high speed inside of a casing. The water enters at the hub, and is thrown outward by the blades to outlet in casing.

Fig. 6.—Centrifugal type.

CHART NO. 94—The Two Water Cooling Systems; the Thermo-Syphon and the Force **System. Water Circulating Pumps. Purpose of a Radiator.**

Note—There is no chart 93—(error in numbering).

**Circulating Pumps.

Practically all pumps are driven by a gear on the crank shaft or cam shaft, so that the motion is positive, and without slipping. All **forced** circulating systems must use a circulating pump.

There are three types of circulating pumps, in general use, the "gear type," the "centrifugal type" and the "rotary type." (see page 186.)

Radiators.

Radiators must be used with either the thermo-syphon or the force system. They are usually placed in front of the engine mounted on the frame, but in a few foreign makes of cars (fig. 3, chart 94) they are placed back of the engine next to the dash.

There are numerous modifications and types of radiators, but are divided into two general types; the "cellular or honeycomb" and the "tubular." (see page 190.)

A tubular radiator is one comprised of a series of tubular water passages. These tubular passages may be arranged horizontally, vertically, at an angle; or bent in a zig-zag fashion that brings about a combination of the horizontal and vertical, or oppositely disposed angular flow of water through the tubes; the object of the latter generally being to imitate or bring about the appearance of the cellular construction. Several tubular radiator constructions are shown in fig. 5, chart 96. It will be noticed that many of these have the true honeycombed appearance.

A cellular radiator is one comprised of a large number of individual air cells, any one of which may be removed and replaced by another in case of leakage. The air cells may be entirely surrounded by water when the radiator is in operation and the course of the water circulation through the radiator is not confined to any definite horizontal, vertical or angular course. Several types of cellular radiator construction are shown in fig. 4, chart 96.

A honeycomb radiator is a term applied to a cellular type of radiator, therefore one has the option of calling a cellular type of radiator a honeycomb type.

In order to grasp the difference between a "cellular" and "tubular" construction, it must be borne in mind that in the radiator the hot water enters at the top, passes downward through it and out at the bottom to the water jackets, becoming cooler in its progress.

In a "tubular" radiator, if vertical tubes are used, the water can pass downward through all of the forty or more tubes. If one tube becomes clogged up, all of the water must go through the other thirty-nine. Each tube is a separate path through the radiator.

In the "cellular" radiator the water passages constitute a system of spaces or cells much like the cellular construction of plants or the wax comb in which honey is stored. Usually cellular radiators are formed in three or four divisions, as indicated by the horizontal lines across the radiator, see upper right hand corner, chart 96. Where these lines cross the radiator there are open horizontal passages through which the water may flow from one side to the other. In each division there is a series of zig-zag water spaces. In some types these spaces are really zig-zag tubes, but in others they offer not only an up and down path for the water, but also interconnect to give a horizontal flow as well.

Tubular radiators may be built up of tubes placed either vertically or horizontally, and which run through fins, as shown in fig. 5, chart 96, to assist in radiating the heat. The true cellular or honeycomb type of radiator is not only more efficient, but is more expensive to construct and is found more generally on the higher-priced cars.

Fans.

In order to cool the water sufficiently, a fan, driven by a belt, attached to a special bracket on engine, is shown in figs. 6 and 7, page 188.

Fan adjustment: the belt can be tightened by raising the fan by an **eccentric** adjustment, or by bodily lifting the fan and its bearing and tightening a bolt holding it.

The belt should be kept tight. Slack fan belt often causes **overheating.** Ball bearings are usually provided and they should be kept **well oiled**—(this is quite often overlooked).

The fan draws a current of air through the passages in the radiator (see fig. 9, chart 94), in addition to that driven through it due to the forward motion of the car.

There are two types of fans in general use; the 4 blade and 2 blade—see chart 97.

Regulating the Heat of the Water.

A damper or shutter arrangement is shown in fig. 10, page 188. As stated on page 155, **heat** is necessary to vaporize the low gravity gasoline now used—especially when starting engine, otherwise raw gasoline will be drawn into engine and produce carbon which eventually causes overheating and other troubles. (see pages 205 and 623.)

One method to produce heat quicker is to close shutters per fig. 10, page 188. The water will then become heated quicker than if a circulation of air was drawn through radiator. After "motometer" shows proper temperature, the shutters are opened, air circulation begins and temperature becomes normal. Control is from seat. **This method and that of heating the intake manifold and drawing warm air into carburetor** are modern heating methods. (see pages 155, 157 and 159.)

Control of Water Circulation.

A water thermostat is another device which will assist in heating the water quicker. It is placed in the path of the water circulating system. When water is below a certain temperature it closes a valve and stops circulation, when above a certain degree, it opens valve and starts circulation (used only with pump system—see page 130, fig. 2). About 170 degrees Fahr. is conceded best temperature. Radiators of present day are made with ample capacity so that the overheating will not occur from lack of radiation.

Temperature indicator—see fig. 9, page 188.

A condenser, to prevent loss of alcohol—see page 730.

**See foot note bottom page 185.

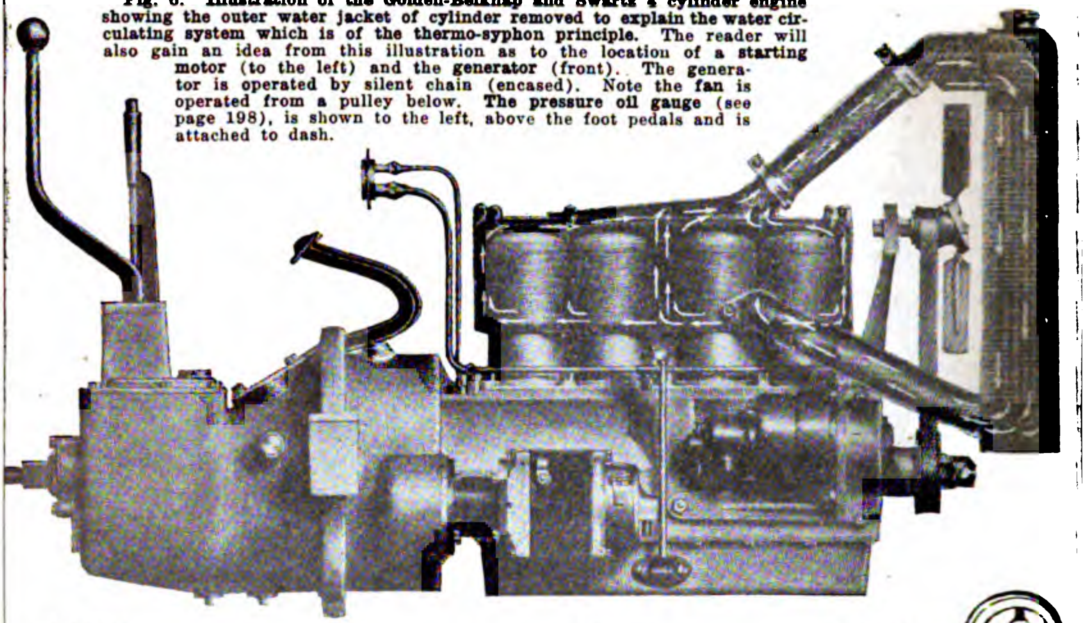


Fig. 6. Illustration of the Golden-Belknap and Swartz 4 cylinder engine showing the outer water jacket of cylinder removed to explain the water circulating system which is of the thermo-syphon principle. The reader will also gain an idea from this illustration as to the location of a **starting motor** (to the left) and the **generator** (front). The generator is operated by silent chain (encased). Note the **fan** is operated from a pulley below. **The pressure oil gauge** (see page 198), is shown to the left, above the foot pedals and is attached to dash.

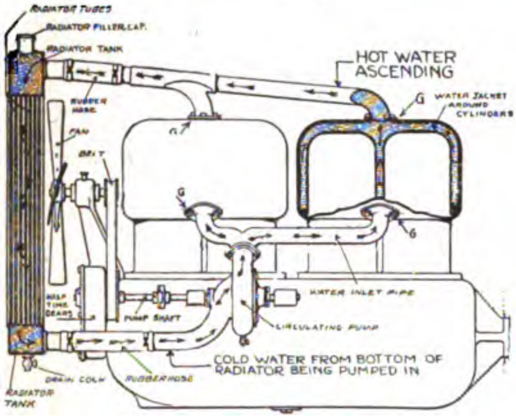
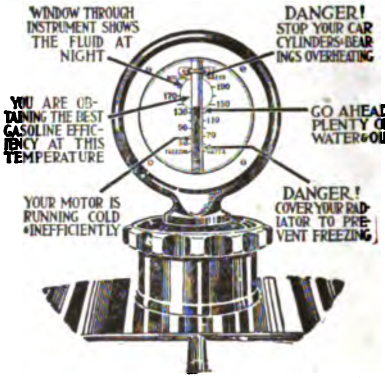
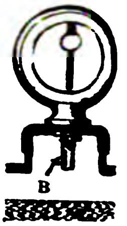


Fig. 7. This illustration shows how the pump shaft on the forced water circulating system is usually driven, also the fan. "G" are gasket connections which must be kept tight—usually made of an asbestos composition. (This is a force system.)


WINDOW THROUGH INSTRUMENT SHOWS THE FLUID AT NIGHT
DANGER! STOP YOUR CAR CYLINDERS & BEARINGS OVERHEATING
YOU ARE OBTAINING THE BEST GASOLINE EFFICIENCY AT THIS TEMPERATURE
GO AHEAD! PLENTY OF WATER & OIL
YOUR MOTOR IS RUNNING COLD & INEFFICIENTLY
DANGER! COVER YOUR RADIATOR TO PREVENT FREEZING



The thermometer bulb (B) does not extend to the water (W) The temperature of the vapor above the water is indicated.

Fig. 9. A temperature indicator—the Boyce moto-meter: A very useful device for warning the driver when his engine is overheating, is called a "motometer." This device is placed on the radiator cap. The fluid in the tube reaches different levels according to the *temperature. These figures can be seen from the drivers seat. If the level of the fluid reaches too high a point the driver is warned to stop and locate the trouble before serious trouble develops. In this instance, first determine the different causes of overheating and try first one, then the other until the trouble is found. If you think the trouble is in the lack of lubrication, lack of water or too much gasoline feeding at carburetor: examine each and remedy the trouble and watch the results. ***A distance type moto-meter** is also made which can be placed separate from radiator and is adapted for use on aeroplanes, motor boats, tractors, etc. (Boyce Moto-Meter Co., Long Island City, N. Y.)

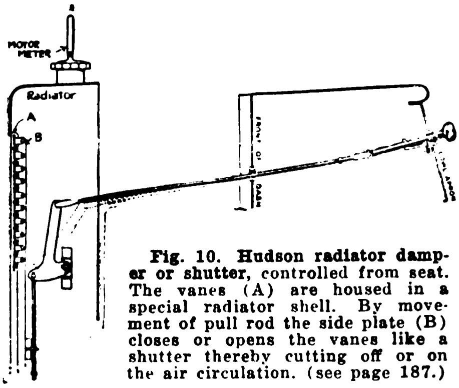


Fig. 10. Hudson radiator damper or shutter, controlled from seat. The vanes (A) are housed in a special radiator shell. By movement of pull rod the side plate (B) closes or opens the vanes like a shutter thereby cutting off or on the air circulation. (see page 187.)

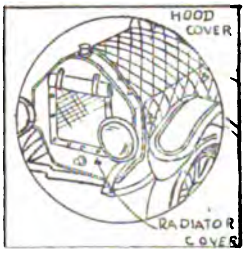


Fig. 8. Radiator cover over the cooling surface of the radiator during cold weather is advisable. The roll in front on the radiator cover can be lowered or raised during cold weather, until engine warms up. **Some merely tie a piece of card board over the lower front** of radiator and keep it there during extreme cold weather.

Hood cover: During cold weather the hood cover is advisable, as it tends to retain the heat under the hood.

CHART NO. 95—Example of a Thermo Syphon Water Circulating System. Location of Pump on Force System. The Temperature Indicator (Motometer). The Radiator Damper or Shutter.

*High altitudes, say 10,000 ft. above sea level, boiling point of water is reached about ⅛" below point indicated at top of instrument. *See page 921.

Air Cooling.

The object of cooling is to remove the excess heat from the cylinders. There are only a few cars on the market in which this is accomplished by the air direct, without the use of water.

Air cooling, however, is confined principally to **small engines**, as motorcycle and cycle-car engines. Air cooling is not successful with large cylinders. It is necessary to give the cylinder a large surface on which the air may act, and the usual method is to make it with deep flanges projecting from the walls and head (as well as the valve chambers), which become heated, as they are part of the cylinder. (See fig. 6, chart 96.)

When in motion, the current of air blowing against the flanges drives the heat away.

Air cooled engines have small cylinders, and must run at a high speed to develop their full power.

****The Franklin air cooled engine** is about the only successful engine for automobile pleasure cars employing the air cooled method. The six cylinders are 3¼ bore and 4 in. stroke, giving a formula horsepower of 25.3.

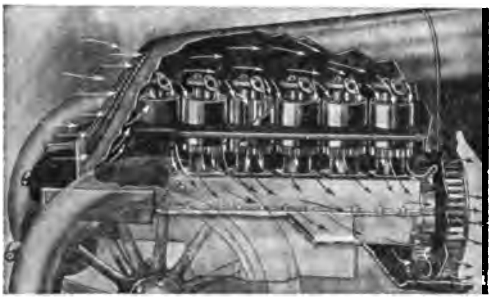


Fig. 1—Direct air cooling of the Franklin. The fly wheel is the only moving part of cooling system.

Vertical steel fins are made integral with the individual cylinder casting, by having the iron poured around the strips of steel. Very light aluminum jackets guide the air draught downward from the heads of the cylinders.

By referring to the illustration the path of the air is shown, first through hood, thence over and down through the air jackets. The air is then deflected downwards and out through the fly wheel blades.

Note the vanes in fly wheel which create a suction equal to 2,200 cubic feet every 60 seconds; a continuous flow of air literally wiping the heat away. It is stated that the heat on a Franklin engine is about 350° Fahr., see fig. 4, page 157 for Franklin exhaust heated inlet manifold. This heat is shut off after engine is warmed up.

The Franklin at one time employed auxiliary exhaust valves to assist in dispelling the heat of explosion from the cylinder as rapidly as possible. This method, however, has been discontinued.

A forced draught air cooling system (fig. 7, chart 96), formerly used years ago on a prominent make of car. With this system the circulation of air was forced through jackets, placed around each cylinder, open at the bottom and top, being connected to a pipe from a centrifugal air blower or fan. The forced air passed the radiator flanges, and out at the bottom. In some respects, this principle is similar to the Franklin.

The different methods of air cooling are summed up as follows:

(1) By having a large radiating surface by means of cast flanges or gills, inserted pins or tubes. (2) By using extra large exhaust valves, so as to cool the combustion space between power strokes. (3) By combining large radiating surfaces with low speeds in multiple-cylinder engines. (4) By the use of auxiliary exhaust ports, combined with surface radiation. ((5) By forced draught of air circulating through an air jacket around the cylinder.

Water Cooling Troubles.

***Overheating:** Assuming that the design and the construction of the engine, including all features of the cooling system, are correct, then, **outside of leaks, insufficient water and bursting of the water jackets from freezing, overheating is the final result of all troubles from the cooling system,** and overheating is due to either or all of these **secondary** troubles which may in turn originate from a number of **primary** causes.

Secondary causes: First, the circulation of the water through the system; **second,** the conductivity of the heat through the walls of the cylinders or radiator tubes; **third,** the passage of air through the radiator and around the cylinders.

Primary causes of overheating in both thermo and forced circulation: (1) Insufficient water supply in radiator; (2) constricted holes in gasket where pipe connects to cylinders and on pump; (3) frayed hose connection; (4) incrustations or lime deposits on walls of cylinders or radiator tubes; (5) mud between fins or cells of radiator; (6) water frozen at bottom part of radiator.

Overheating causes in forced circulation: (1) Broken fan belt; (2) fan belt too loose; (3) tight fan belt bearing; (4) improperly bent fan blades; (5) broken pump shaft; (6) lost pin from pump shaft coupling; (7) lost pin from pump shaft gear; (8) lost pin from internal pump mechanism; (9) pin holding pump shaft sheared off, but shaft continues to revolve.

Other causes for engine heating: A shortage of lubricating oil or a poor grade; too rich a mixture with a retarded spark will cause overheating; the spark bears a fixed relation to the mixture, which is best learned by experience. The valves being set wrong will also cause heating; for instance, if the exhaust valve does not open and close at the right time the heat or burnt gas will not be discharged properly. Preignition, want of compression, old oil being used too long; (cheap oils are false economy and only the best grade should be used). Improper driving will produce heating, particularly in hilly districts, by hanging on to the third or fourth speeds when ascending inclines and so causing the engine to labor, and running on retarded spark.

In some engines an inclination to overheat gradually develops as the car gets older, and appears to defy all efforts to remedy by means of carburetion or ignition.

This may be due to the clogging of the cooling system with incrustation or deposit in the walls of cylinder jackets and water system generally.

---

*Also see index for "spark control and overheating." **See index for "Franklin engine."

**The Holmes Automobile Co., Canton, O., are also manufacturers of an air cooled car with many distinctive features.

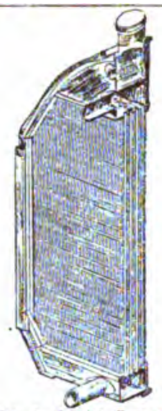


Fig. 1—Tubular Type of Radiator.

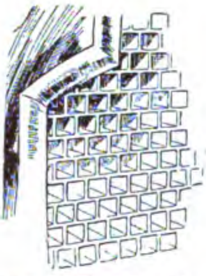


Fig. 2—Cellular Type of Radiator.

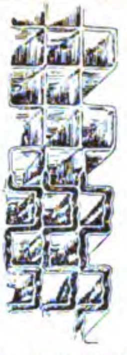


Fig. 3—Honeycomb Type. This is really a tubular type. Tubes are zig-zag shape, giving the honeycomb effect.

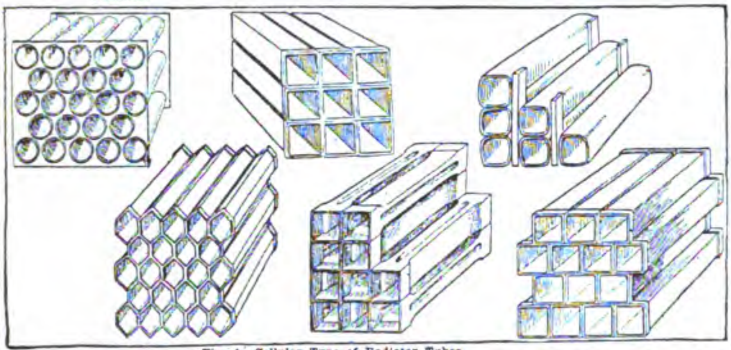


Fig. 4—Cellular Type of Radiator Tubes.

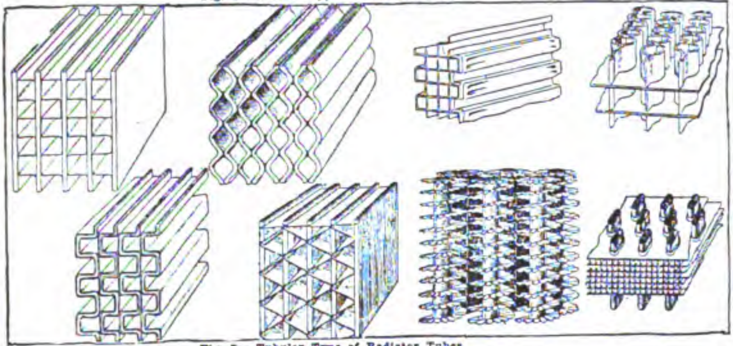
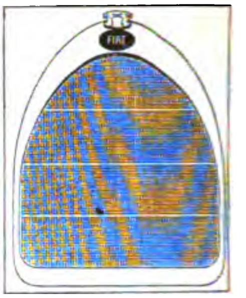


Fig. 5.—Tubular Type of Radiator Tubes.

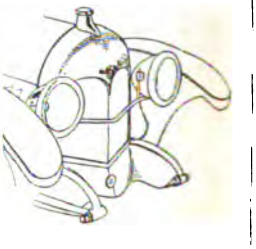
The radiator is usually placed in the front of a car. The water, after leaving the lower part of radiator, passes through the water jacket of engine, where it becomes heated, and is then forced through the radiator tubes where it is cooled. The water is cooled by air currents passing around the tubes, extracting the heat, in proportion to the available cooling surface exposed.

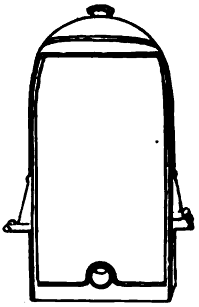
The **cellular** type is generally used on pleasure cars and the **tubular** type on commercial cars.



The FIAT design of cellular radiator.

Other designs of cellular type radiators shown below.





The long narrow radiator is quite often used on racing cars.

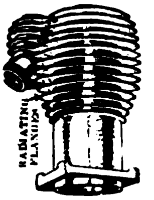


Fig. 6. An air cooled cylinder, with radiating flanges. Type of cylinder usually employed on motorcycle engines. While in motion the air current carries off the heat deflected from the flanges.

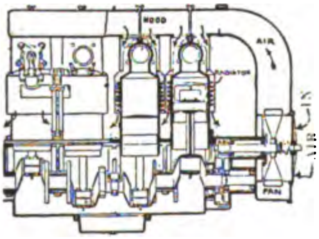


Fig. 7. A system of air cooling by a forced draught method—formerly used on a prominent car. This principle is now obsolete. See the Franklin method, the only successful air cooling method in use at the present time.

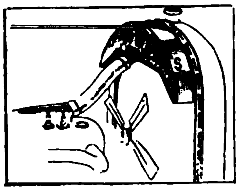


Fig. 9. Extension tank—also called a syphon tank: This tank (S) on the thermo-syphon system is used to give a greater body of water for the double purpose of more thoroughly absorbing the steam emerging from the water jackets and to maintain a constant level.

With a pump system the volume of water is quite as essential as the cooling effectiveness of the radiator—therefore it is a desirable feature on all radiators.

To determine if the boiling is due to stoppage of circulation, feel of radiator; it should be slightly hotter at the top than at the bottom, but if clogged there will be a pronounced difference in temperature.

‡Water Boiling.

Water boils at 212 degrees Fahrenheit at atmospheric pressure. For this reason the cooling system of an automobile is so designed that the water is at the temperature of about 170 to 200 degrees under average running conditions.

This leaves quite a margin before the boiling point is reached. **When climbing a hill with a retarded spark the engine naturally becomes warmer** and for this reason the margin is left although as a matter of fact the engine would run at a higher efficiency if the temperature of the cooling water could run higher. If the cylinders are kept too cool, it means that too much heat is being withdrawn from the explosions. On the other hand, if permitted to become too hot, power is lost through:—(a) the entering gases being unduly rarified or prematurely expanded, and thereby containing less combustible material per volume; (b) friction due to the thinning of the oil. and probable binding or seizing of the piston or bearings. **Therefore the best water temperature to maintain is about 170 degrees.** (see fig. 9, page 188.)

Radiator Damper.

Improvements in water circulation are shutters, as per fig. 10, page 188. A very efficient heat conserving device. Engineers saw the futility of putting gasoline into an engine to get heat and at the same time permitting great drafts of cold air to be drawn through the radiator to drive away the heat. Therefore the shutter was devised to retain the heat, especially on starting during cold weather.

††Water Thermostat.

In addition to the radiator shutters, we have the heat "thermostatically" controlled, which is another great advance to conserve engine heat. See fig. 2, page 130. In addition to these devices, warming devices have been invented to deflect the heat from the exhaust manifold into the air chambers of the carburetion, as per pages 157 and 159.

Miscellaneous Cooling Troubles.

Water: In localities where pure water is not easily obtained it, is well to strain the water through muslin. Soft water is better than hard water, because the latter is apt to deposit a scale on the walls of the radiator. The best water to use is rain water.

It is very hard to tell whether water is hard or soft, but the following may be used with success: Take a quantity of water in the hands and go through the motion of washing. If it is difficult to rub the hands together the water is hard. Ordinary city water is generally hard to some extent, but is not as bad as that which is found in streams. Rain water is very soft and for that reason is desirable for automobile use.

Many automobilists have a rain catcher on the roofs of their garages, while others depend on the old-fashioned rain-barrel. The water should be filtered first, however, if it is taken from the roof, as it is apt to contain impurities. But even with fairly soft water the monthly use of a soda solution will prevent harm (this applies only in districts where the water is unusually hard).

The pump requires no attention, other than to see that it does not become choked by using dirty water. There is a "packing nut" on the shaft, which, if the pump should ever leak around the shaft entrance, should be repacked. This can very easily be done by turning off the packing nut, removing the old packing and rewinding the shaft with a few inches of "well graphited packing" and tightening up the packing nut. The packing should be wound on in the same direction as you turn the nut to tighten it.

The fan requires no particular attention, except oiling. Sometimes the belt gets loose and causes the fan to slip and not to turn as rapidly as it should, causing overheating of engine. If this happens, loosen the nut which holds the eccentric arm of the fan, raise the arm slightly and retighten the nut. This will tighten the belt. Note—This nut frequently has a left hand thread. Don't tighten too tight as you are liable to crack the fan support. (see page 788.)

†Cleaning radiator: A good way is to dissolve a half pound of lye in about five gallons of water. Strain through a cloth and put in the radiator. Run the engine for five minutes, then draw off the cleaning mixture. Fill with clean water and run the engine again; remove the liquid once more, and finally refill the cleaned cooling system. Avoid the use of more powerful chemicals. Ordinary baking soda can also be used, by mixing ½ lb. to 4 gallons of water. It is best to dissolve the soda in warm water before pouring it into the radiator, otherwise the crystals drop to the bottom. If the cooling system seems to be very dirty as far as scale goes, it would be very wise to run the soda solution through it several times in order that all of the scale will be removed.

It is a good plan to drain the water from the radiator about once a month and refill with clean pure water (soft water, if possible), opening the drain cock and continuing to pour water in after the system fills in order to flush it out thoroughly letting all accumulated dirt, etc., run out. An effective way to do this is to keep on filling the radiator while the water continues to run out below; when the water begins to look clear, stop. Close the drain cock after you are satisfied that the system is thoroughly clean. **Oil must not be allowed to get into the cooling system,** for it interferes with radiation.

Cleaning a muddy radiator: If the air spaces of the radiator become clogged with mud, after driving over dirty roads, do not attempt to remove the mud with a screwdriver, wire, or other metal instrument. Instead, soften the mud with water. The best way is to wash the radiator by flushing a stream of water from a hose through it from the rear. In doing this, take care not to let water get into the magneto, which is apt to be short-circuited in that way.

**Leaky Radiators.

Leaks in the radiator are often hard to reach. They are detected by the steam arising from the water that flows through the leak and down the outside of the radiator. The great facility with which the cooling water will boil after the radiator has been refilled is another clue which, although it is common to all leaks in the system, will lead the operator to the point at which it occurs.

Testing for leaks: see pages 194 and 715.

The act of scouring out the circulation system with a strong alkali, such as soda, will sometimes tend to seal up any small leaks, and it might also be effective for a slight crack in a water jacket as the soda, coming in contact with the iron, would form an insoluble filling and prove even better than rusting up the crack.

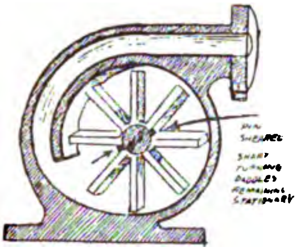
The standard honeycomb radiator is somewhat prone to these leaks; the metal is so thin and the joints so numerous, and it is not always possible to have a leak soldered up at the required time. In this case recourse can be had to a small useful accessory known as a "leak preventer." It consists of a couple of small plates or washers with a piece of sheet rubber fixed on; these plates have hooks so that a spiral spring can be fixed on to draw them together. The spring is threaded through the aperture at the leaky cell, the plates hooked on, and thus held firmly up against it. Most accessory houses keep them, and if the car has a honeycomb radiator it pays to carry several of these devices. The construction of this type of radiator lends itself to a repair of this kind, but leaks in other forms of radiators, when they occur on the road, are rather troublesome. Even soldering them is by no means an easy job, there being such a large mass of metal that the solder cools as soon as it touches it.

---

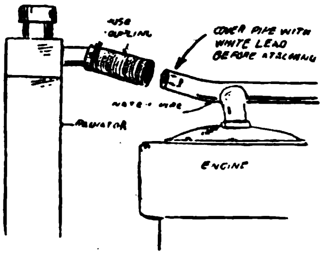
†See page 789. ††See also page 860. ‡Water heats quicker at high altitudes, see page 582.

Many small leaks or drips about the cooling system can be traced to loose rubber hose.

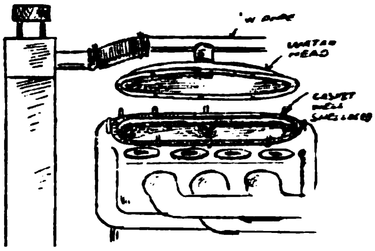
**Small water leaks in the water circulating system can be stopped by the use of preparations made for the purpose—see foot note page 715. One manufacturer states that ordinary bran mixed with the water will stop a slight leak. The writer has never tried this.



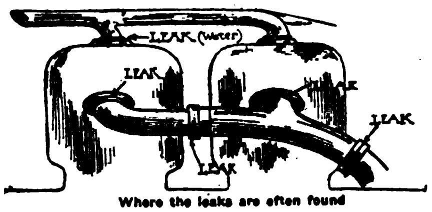
Examine circulating pump shaft and see if pin is sheared; if engine overheats.



When placing water hose back, put white lead on the end of pipe.

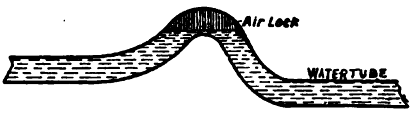


When placing water head casting back on top of cylinder use shellac or white lead on the gasket.

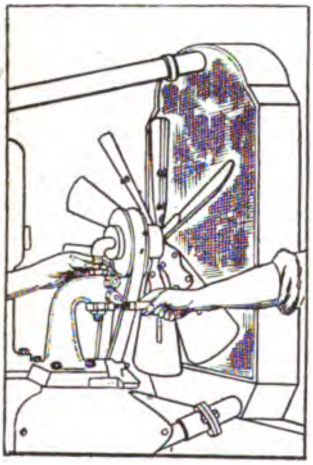


Where the leaks are often found

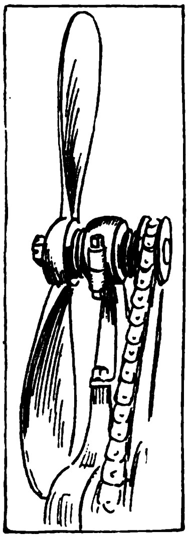
If there are water pipes instead of a casting; use shellac or white lead on the gaskets. Screw up gaskets tight, but not too tight and strip the threads of cap screw.



***An air lock** often occurs in the top of an inverted U bend in the water tubing of an engine, which means that almost the whole flow of water has been stopped at that point. No amount of pressure from the water, can dislodge the air, because its only effect will be to compress the air in the top of the bend. The remedy, is either to release the air at the top, by putting in a pet cock, or else to empty the water and carefully refill.

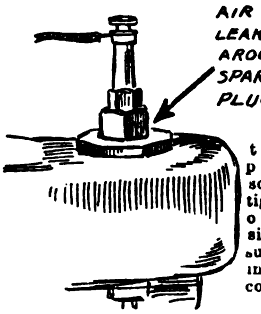


If engine heats, or water boils over, examine the fan belt, see that it is tight and fan runs up to speed. There is usually an adjustment for taking up slack belts. A little Fullers earth on a greasy belt, will make it grip if it slips.



A two-blade fan—called the propeller type.

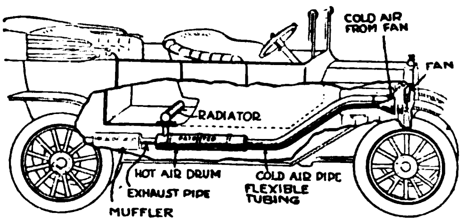
Use rain water for the radiator, if there is a lot of lime in the water and it is constantly clogging up. See page 191, "cleaning radiator."



Make sure that spark-plugs are screwed in tight. Loss of compression will result, and missing, a natural consequence.

Heating the Car. There are Three Heating Principles:

(1) hot water; (2) exhaust gas; (3) hot air. The two former mentioned are explained in chart 98.



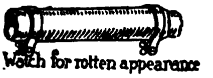
The Brickley hot air heater takes the air from the fan through a funnel opening, and a flexible metal hose; drives it through a metal jacket 24 to 30 inches long, which covers the "piping hot" exhaust pipe, and warms it thoroughly. Then drives it through a 1¼-inch opening in the floor of the car, into a tubular register, along the back edge of the front seat; sending a continuous stream of heated air into the car. (Exhaust gases not used.)

CHART NO. 97—Cooling Troubles and Remedies Illustrated: Fans. Heating a Car.

---

*When filling radiator which is empty, open pet cock on water pump for a moment to prevent air pocket.

Another plan is to carry a small box of white lead of a suitable consistency. If the water is not coming through quickly, a temporary repair can be made with this, especially if a piece of tape can by any means be bound over the repair. It is often possible to hammer up or plug a leakage in a tank or radiator.



****The rubber hose and its connections are often a source of leaking.** When the hose is worn it will become ragged-looking on the outside. The rubber which surrounds the fabric will commence to have a torn appearance and the water will seep through the fabric. There are two ways of remedying this; one is renew the hose and the other is to repair old hose. The first is the better and more permanent repair. In doing this a piece of hose of the same thickness and length as that now in place is secured. The clamps which hold the hose in place are removed. The new hose is slipped in place and the clamps put over it and screwed up tightly, if they are of such a type that they are secured by a small bolt. If not, the operator will do very well to obtain same. The cost will be small and they are easily removed, being far better for this work than wire or any similar contrivance. Paint all threads of water pipes with white or red lead.

Cylinder leaks: A slight leakage of water from the jacket into the cylinder may be caused by a crack, but more usually will be found to be simply a defect in the seating of pipe plug fitted in the heads of many engines.

***A crack in cylinder—when on the inside, is** difficult to locate. Its action may be of such a nature as to be only operative when the engine is at full working heat; due of course to the expansion. It is generally accompanied by misfiring and boiling. The former owing to leakage of water into the cylinder and the latter owing to the exploding gases (at a very high temperature), being forced into the water jacket.

The best means of detection, is to fill radiator entirely to top of cap, run the engine till hot, then stop it and turn it over by hand, against the compression in each cylinder, if there is a crack: bubbles will appear at the cap. So by noting the compression of each cylinder, the defective one can be located.

Slight leaks inside of cylinders have been remedied by rusting if the hole is very small. See page 713, "rusting a hole in cylinder."

Gasoline leaks: A temporary repair for a slight leak in a gasoline tank can be made by applying ordinary soap. Such a repair may last till the defective part can be soldered. Leaks at gasoline taps can generally be cured by screwing up the nut securing the tap plug, or by grinding in the tap with crocus and oil.

Cold Weather Precautions.

In winter, a water cooled engine must be carefully guarded against freezing, for if the water freezes in any part of the system it will cause the breakage of piping or radiator, or crack a water jacket. When the engine is running, the water is kept warm, therefore no danger; it is when engine is stopped that care must be taken.

When leaving the car for several days, during cold weather, the safest plan is to drain the water out of all parts of the system, cocks being provided for the purpose at the lowest point of the system, usually at the **bottom of radiator.** The engine should be run for a few minutes to make sure all the water has been removed.

†Non-Freezing Solutions.

To prevent the water from freezing when it is not desirable to drain it out, either wood alcohol, denatured alcohol or glycerine may be mixed with the water. The alcohol mixture is as follows:

††Wood Alcohol and Water.

10° above zero; 80% water, 20% alcohol.

Zero; 75% water, 25% alcohol; sp. gr. .969.

7° below zero; 70% water, 30% alcohol; sp. gr. .963.

22° below zero; 60% water, 40% alcohol; sp. gr. .951.

If denatured alcohol is used, increase percentage in above table by approximately 15.

For evaporation—use 75% alcohol to 25% water—as the alcohol evaporates quicker. This does not apply to loss by leaks or boiling over.

A hydrometer can be used for mixing and maintaining correct solution, by first testing the original and keeping it up to a standard of 1250 gravity.

Glycerine and Alcohol.

30 to 15 above zero:	
Alcohol	10%
Glycerine	10%
Water	80%
Not lower than 5 below:	
Alcohol	15%
Glycerine	15%
Water	70%
Not lower than 15 below:	
Alcohol	17%
Glycerine	17%
Water	66%

Where glycerine is used only alcohol need be used for evaporation, which should be added occasionally. The glycerine does not evaporate with the water. A simple solution of alcohol, while it is not injurious in any way, lowers the boiling point of the water. Consequently on warm days, with the car standing and the engine running, the solution will tend to boil easily and evaporate. The boiling point of denatured alcohol is about 10 degrees higher than that of wood alcohol.

**The use of glycerine raises the boiling point of the solution. It is more expensive than alcohol, (a pound of glycerine costs 88½c. There are 8 lbs. to a gallon) and is slightly injurious to rubber. A combination solution of alcohol and glycerine in water is most satisfactory but expensive.

There are three grades of alcohol; denatured which is a disguised grain alcohol of first still, (not suitable as a beverage). It sells for $1.05 per gallon and has a higher boiling point than wood alcohol. Wood alcohol sells for $1.60 per gallon and has a lower boiling point. The high proof or double still grain alcohol used as a beverage is too expensive. Therefore, denatured alcohol is cheaper and the proper thing to use. **††Alcohol boils at 172°. Therefore don't overheat engine.**

Calcium chloride or any alkaline solution, is injurious to metal parts.

If **calcium chloride** is used, then the proportions are: 3¼ pounds to a gallon of water for zero weather, and 4 lbs. for 17° below. In using calcium chloride it is the acid in it which attacks the metal. This can be neutralized by adding ammonia or soda ash until blue litmus paper no longer turns red when dipped into solution.

If the cooling water should freeze; the usual indication of a frozen radiator is steaming excessively. It would appear that the steam or heat would thaw it out and start the circulation again, but such is not the case. When the water freezes don't run engine to try and start circulation. Find the nearest warm garage and, if possible, turn hot water onto the bottom of radiator until steaming ceases, as a radiator in this instance usually freezes at the bottom first. (see bottom of page 788.)

In addition to non-freezing solution, it is always well, when making a stop, to cover hood and radiator.

Also draw in a full charge of gas by speeding up engine and opening throttle before stopping.

In carbide gas lighting generators using the water drip, a suitable non-freezing solution is alcohol and water, same proportion (no glycerine).

---

*See pages 713, 715. ††See page 585 "freezing point of gasoline, alcohol," etc. **Prices not now correct.

†**Anti-freezing powder** is used extensively. Sold by all supply houses. **Kerosene is not suitable for non-freezing** for reasons given on page 585. ††On airplane engines, where hose connection is made to the pipe it is not only connected with a connector, but connection is taped and shellacked.

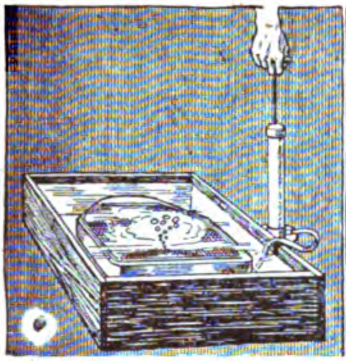


Fig. 1.

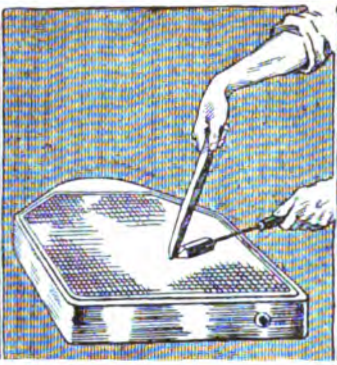


Fig. 2.

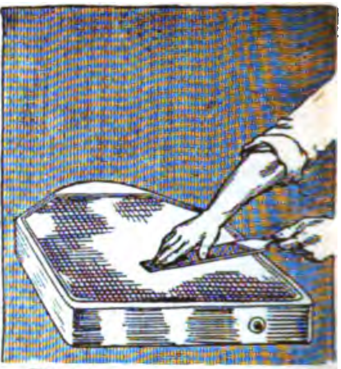


Fig. 3.

Radiator Leaks.

Testing for leaks: It is hard at times to detect the exact spot at which a leak occurs in a radiator. When this is the case take the radiator off and after plugging all but one of the openings, run the tube of a tire pump through a cork and then place the cork in this last opening. Place the radiator in a tub of water (per fig. 1) and then pump air into it. Bubbles will issue from the points of leakage. This should be immediately marked so that it can be found again after the radiator is removed from the water. The leak is then repaired by soldering as per fig. 2 and filed smoothly as in fig. 3. When soldering, remember that the metal must be scrupulously clean before the flux is applied or else the solder will not hold.

Small leaks are dealt with on pages 191 and 193, also see page 715. It is advisable to have this work done by a specialist.

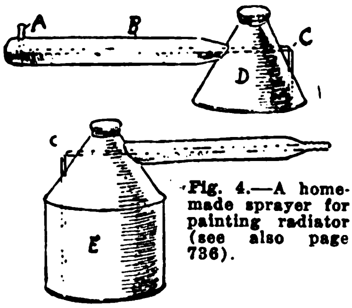
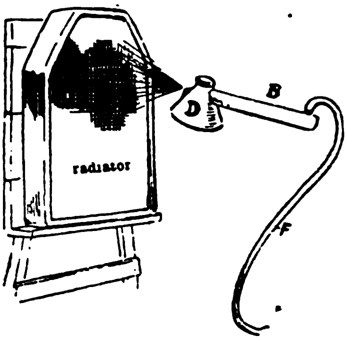


Fig. 4.—A home-made sprayer for painting radiator (see also page 736).

Fig. 5.—Showing how the paint is sprayed on the radiator (see page 509, for paint).



Painting a Radiator.

It is very difficult to paint a radiator quickly and thoroughly with a paint brush, and the usual plan, where a great deal of the work is done, is to dip the radiator in a paint solution. A very satisfactory job can, however, be quickly done with a spraying outfit. A very simple and home-made device is here illustrated.

It consists simply of a construction such as is shown in fig. 4, in two sizes and designs, which comprises a can for the paint, consisting of a mixture of lampblack and turpentine, a hollow cylindrical tin handle attached to the can, an air pipe (A) passing through the handle and through can, as indicated by the dotted lines; and another similar pipe or tube extending downward at right angles from the one end of the horizontal tube into and near to the bottom of the can, as is also indicated by dotted lines.

It is a simple adaptation of the principle employed in most atomizers. When a stream of air is forced through the air tube, passing through the handle and directed across the opening (C), at top of the vertical tube the fluid from the inside of the can is drawn up and sprayed onto the radiator. It is best to tilt radiator when spraying, so solution will drain off.

Hot Water Heat For Car.

The illustration shows a hot water heater for heating the interior of car. The hot water is taken from the water jacket of the cylinder nearest the dash of the car and is circulated through the heater, whence it returns to the bottom of the radiator, stop cock on intake line. Portions of floor are cut away, allowing the surface of the heater to be flush with the floor.

The radiator heater is made of regular water piping and the housing of aluminum or light cast iron. The top plate is made of aluminum with holes as shown. This system can be used only where there is a circulating pump.

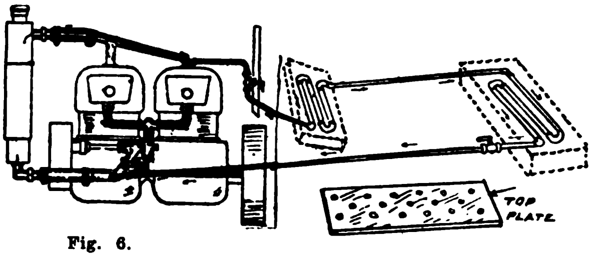


Fig. 6.

The box to hold the heating pipes can be cast at a small cost by a foundry. Sheet aluminum can be secured at the metal dealer.

Another method for heating is to utilize the exhaust gases instead of water. In this instance the pipes would be connected with exhaust pipe instead of the water pipe. Only one side, the inlet would be connected and an outlet is provided for the emission of the gas.

See another plan for heating a car on page 192.

CHART NO. 98—Repairing Leaky Radiator (see also page 715). **Painting a Radiator** (see also pages 194, 509, 736, 584). **Hot Water Heating of Car.**

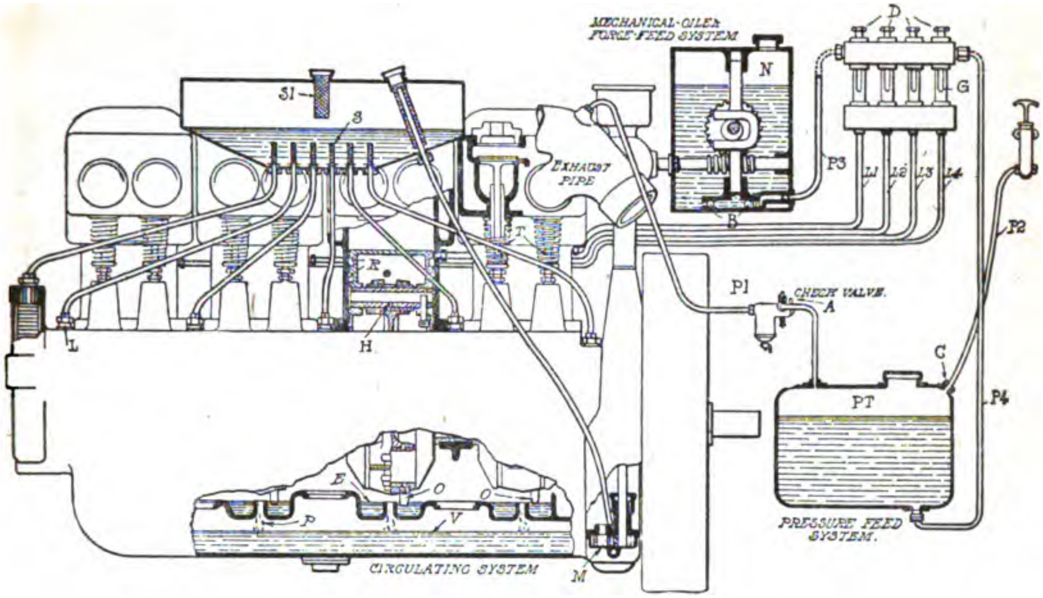


Fig. 1. Some of the early methods of engine lubrication. There are four different systems shown on this engine in order to clearly explain each system. The systems are enumerated and described below.

Explanation of the Four Engine Lubrication Systems—Above.

First: We will follow out the splash system; we will assume oil is placed in crank case through breather pipe. The scoops (O) on end of connecting rods pick up the oil from troughs (E), and splash it to the various parts.

Second: Force feed, splash and gravity. We will assume the splash system just described is a part of this system. The overflow passes to reservoir (V), it is then forced by pump (M) to a gravity feed reservoir placed on top of engine. The passage is then through the different pipes (S to L) to the bearings, thence back to the troughs (E) and reservoir (V). This system would also be termed a circulating system, as the oil is in continual circulation.

Third; Separate forced feed and splash. The mechanically operated pump is driven by belt, chain or bevel gears. There are several small pumps under the oil reservoir box (N), in fact a pump for each feed; each separate feed is piped to the different parts to be lubricated. The oil passes through a sight glass (G). The oil then passes to bearings and falls to bottom of crank case. The oil reaches a level or height in the crank case so that the connecting rods give an additional lubrication by splash. The amount of oil fed is regulated by drops, through the sight glasses, by the regulation of the screws (D), and depends upon the size of engine and speed. (Note—pipe (P4) is not connected with this system.) This would be termed a non-circulating system.

Fourth: The exhaust pressure feed and splash. This system consists of an air tight oil tank or reservoir (PT). A small pipe (PI) connects the tank with the exhaust pipe. A check valve permits the gas pressure to pass into tank but not to flow back.

The initial pressure is given to the tank by a small hand pump through pipe (P2). After engine is started, the pressure from exhaust is sufficient to force the oil through pipe (P4) to sight feed glasses, thence to the various parts to be lubricated—thence to crank case.

This system, like the third system, requires oil to be fed by drops as it is not pumped over and used again and would be termed a non-circulating system.

CHART NO. 99—Engine Lubrication Systems. The above explains some of the original system of oiling. The modern systems are explained farther on.

INSTRUCTION No 15.

LUBRICATION: Different Engine Lubricating Systems. General Lubrication. Lubrication Troubles. Carbonization. Oil Pumps. Oil Pressure.

Purpose of lubrication: When two parts of a mechanism rub together, it is necessary to use some means of preventing excessive friction, and this is usually done by applying lubricating oil between them. Without a lubricant the friction would cause heating, and the result would be cuts or scratches on the surfaces of the two parts.

Two parts intended to rub together, like a shaft in its bearing, should be made as smooth as possible, for roughness would cause friction that lubrication could not prevent. The more rapid the movement of the parts against each other and greater the pressure the more they must be lubricated.

A bearing in which a shaft is turning at a constant speed requires a constant supply of oil which must be fed to it regularly as required. Too much oil would be wasteful, and too little would permit the bearing to become heated. All the moving parts of an automobile must be lubricated, but as some parts move much more than others and are subjected to greater strain and pressure, the kind of lubrication must be varied to suit these conditions.

Engine Lubrication Systems.

The principal parts of an engine to be lubricated are: **main shaft, cam shaft, crank pin and wrist pin bearings; cylinder walls; piston and piston rings; valves; push rods, etc.**

Methods of engine lubrication may be divided into two general classes; the "circulating" and the "non-circulating" systems.

The circulating systems would be represented by systems having a continuous circulation of oil and is frequently termed the "pump over" system. For instance, a system using a force pump for pumping the oil from the lower part of the crank case to the upper part, with a drain back to the lower part again, would be termed a "circulating system."

A non-circulating system, such as a drip or gravity system, or a mechanical feed; so many drops per minute, depending upon the speed and size of the engine, with no provision for circulating the oil again, would be termed a "non-circulating system."

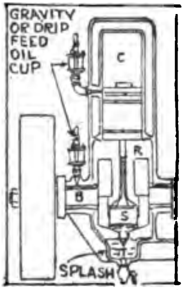
These systems may be combined, which is frequently done. For instance, the combination of a "force feed" and "splash" system.

But speaking generally, the systems can be grouped under: (1) splash and (2) force feed lubrication.

Drip (or Gravity Feed) and Splash.

This non circulating system consists of a drip or gravity feed oil cup placed over the bearings and also on side of cylinder. Special oil cups are required for the cylinder which will prevent the compression, interfering with oil entering side of the cylinder wall.

The oil drips by gravity and the surplus flows to the oil trough from where it is picked up by the connecting rod and splashed to parts above. C is the cylinder and B the bearings. S is the crank pin. The oil in the lower part of crank case is kept at a sufficient level for the connecting rod to pick it up and splash. The filling is done once in a while as required, by pouring the oil in by hand.



The oil cups feed by drops and usually the manufacturer determines how many drops per minute are required.

The oil flow is not controlled by the engine, and each cup is therefore provided with an adjustment, whereby the feed may be regulated when the engine is running, and turned off when it is stopped. This would be classed as a "non-circulating system."

This system is used extensively on two cycle marine engines, and stationary engines. Two cycle engines are also lubricated by mixing the oil with the gasoline through the mixing valve, the mixture being about one pint of oil to five gallons of gasoline.

The Splash System—non-circulating.

The true splash system alone is non-circulating.

The crank case is made oil tight, and oil is placed in it to such a depth that the bottom end of the connecting rod dips into the oil, and splatters it to all parts of the crank case, the bearings, and the lower part of the piston. An oil groove is sometimes cut around the lower part of the piston, and the oil splashing into this is carried upward and distributed on the cylinder wall and rings. There are no oil troughs in this system.

---

*See "Specifications of Leading Cars" for the type of lubricating system used on leading cars.

As the oil is used, more must be added to the crank case to keep the necessary level. This is done either by means of (1) a hand pump connecting the crank case to an oil tank or (2) by an oil cup that drips a certain amount of oil into the crank case every minute, or (3) by filling through a breather pipe.*

With the hand pump, the driver gives it a stroke or two every few miles, experience being his guide as to how often and how much. This latter system, however, is not much used on automobiles, but is extensively used on motorcycles. This system would be termed a non-circulating system.

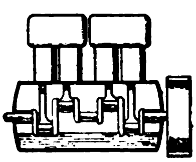


Fig. 1.

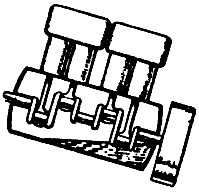


Fig. 2.

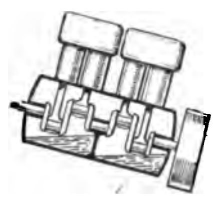
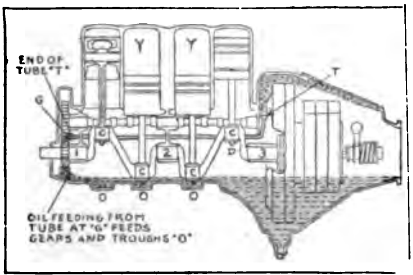


Fig. 3.

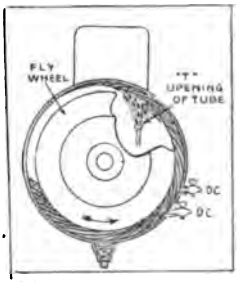
The objections to the splash system are as follows; refer to fig. 1—note the engine is in a level position. As long as the engine remains level the splash system gives fairly good satisfaction, so long as the level of the oil is kept up to the lowest point of the connecting rod where it can be picked up and thrown to the upper part. If, however, the car is in such a position the engine will be tilted, as shown in fig. 2, then the oil goes to the rear cylinder. The rear cylinder is **over** lubricated and the others are **under** lubricated. Even though a "baffle" plate is placed as shown in fig. 3, still there is one cylinder minus oil. Therefore some other means must be employed so that all cylinders will receive their proper share of oil.



The Ford semi-circulating system.

Splash System—semi-circulating.

One method of overcoming this latter mentioned objection is to provide **troughs** (O) under each connecting rod, which is shown in the cut of Ford engine. The troughs retain the oil, even though engine is at an incline. The next method is to keep the oil at a **constant** level in the troughs. This is accomplished by some means of **circulating the oil.** In this instance the constant level of oil is maintained by the action of the fly wheel.



The fly wheel throws the oil to the top of the transmission case where part of the oil is caught by tube "T" and fed by gravity to the cam gears. The overflow coming back tends to keep the troughs (O) filled with oil. This system would be termed a semi-circulating system.

Splash System—circulating.

This system could be termed a "circulating splash system" also a "pump over" system and is the true **constant level, circulating splash system** because the oil troughs are kept at a constant level by a pump.

The operation of a "circulating" or "pump over" oiling system is shown in fig. 6; the main oil supply is contained in the reservoir (R), from which it is drawn by the pump (M) and forced through the pipes or leads (L) to the main crank shaft bearings (G).

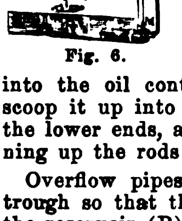


Fig. 6.

The overflow from these bearings is thrown by centrifugal force against the walls of the crank case and cylinders and, as it runs down, is collected by inclined channels (N) which conduct it to troughs.

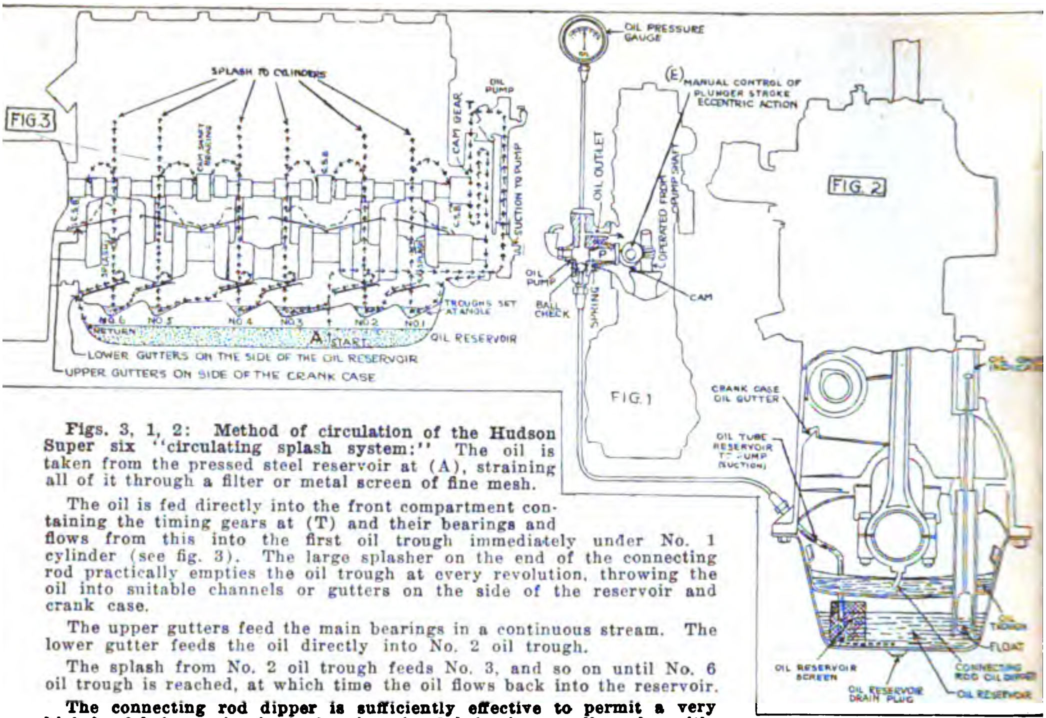
For lubrication of the connecting rod bearings, scoops (S) are fitted to the lower ends of the connecting rods, which dip into the oil contained in the troughs and scoop it up into the crank pin bearings at the lower ends, and through tubes (E) running up the rods to the piston-pin bearings.

Overflow pipes (P) are provided in the trough so that the excess oil can return to the reservoir (R).

The pump (M) is usually a gear type of pump, operated by bevel or spiral gears and vertical shaft from the cam shaft C. On many engines the pump is a plunger type operated by a cam from the cam shaft.

---

*A breather for an engine (see Studebaker, page 71), is a pipe opening connected with crank case, where oil is poured into crank case. The opening is closed by a cap which does not fit tight, but allows the air to enter, and at the same time prevents oil from working out.



Figs. 3, 1, 2: Method of circulation of the Hudson Super six "circulating splash system:" The oil is taken from the pressed steel reservoir at (A), straining all of it through a filter or metal screen of fine mesh.

The oil is fed directly into the front compartment containing the timing gears at (T) and their bearings and flows from this into the first oil trough immediately under No. 1 cylinder (see fig. 3). The large splasher on the end of the connecting rod practically empties the oil trough at every revolution, throwing the oil into suitable channels or gutters on the side of the reservoir and crank case.

The upper gutters feed the main bearings in a continuous stream. The lower gutter feeds the oil directly into No. 2 oil trough.

The splash from No. 2 oil trough feeds No. 3, and so on until No. 6 oil trough is reached, at which time the oil flows back into the reservoir.

The connecting rod dipper is sufficiently effective to permit a very high level being maintained, thus insuring lubrication on all grades without excessive oil consumption. The two center bearings are fed by two troughs each.

The front bearing is fed from the timing gears and one trough, and the rear bearings is fed by two large troughs. It is apparent that all oil which enters at the front end must circulate through the various troughs to the reservoir again (see page 200).

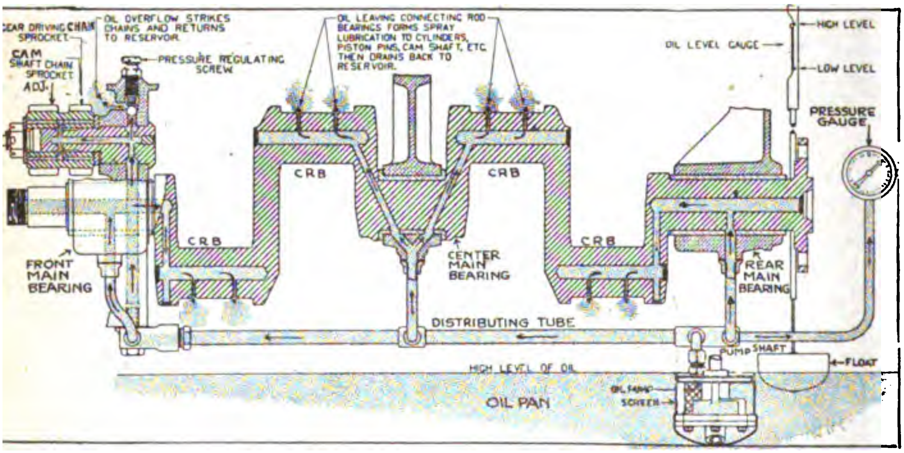

GEAR DRIVING CHAIN SPROCKET
CAM SHAFT CHAIN SPROCKET
ADJ.
OIL OVERFLOW STRIKES CHAINS AND RETURNS TO RESERVOIR
PRESSURE REGULATING SCREW
OIL LEAVING CONNECTING ROD BEARINGS FORMS SPRAY LUBRICATION TO CYLINDERS, PISTON PINS, CAM SHAFT, ETC THEN DRAINS BACK TO RESERVOIR.
OIL LEVEL GAUGE
HIGH LEVEL
LOW LEVEL
PRESSURE GAUGE
CRB
CRB
CRB
CRB
FRONT MAIN BEARING
CENTER MAIN BEARING
REAR MAIN BEARING
DISTRIBUTING TUBE
PUMP SHAFT
FLOAT
HIGH LEVEL OF OIL
OIL PAN
OIL PUMP
SCREEN

Fig. 4: Method of circulation of the King "Full Forced Feed System:" There are no troughs or splash with this system. Oil poured into the filler tube, flows down into the oil pan, filling it up to a height indicated by the oil level gauge on right-hand side in center of engine. From the pan or reservoir the oil is drawn up through the oil pump, which is driven by a vertical shaft from spiral gears on the camshaft. The oil pump itself is surrounded by fine screen so that all oil entering the system is thoroughly strained to remove the dirt or lint that might stop up the oil ducts and cause damage. The illustration shows the principle of the system, and by following the arrows the oil can be traced from the reservoir to the various parts of the engine.

The gear pump at the extreme bottom of reservoir draws the oil through the screen which surrounds it and forces it into a distributing pipe running the entire length of the crankcase. From this pipe the lubricant is forced to each of the three crankshaft main bearings.

From the main bearings the oil is forced through holes in the crankshaft to the connecting-rod bearings. Since, at every revolution of the crankshaft, these holes register with the leads from the distributing pipe, an excess of oil is forced to the connecting rods. where it is drawn off in fine drops or mist onto cylinder walls. A part of this spray, is also utilized for lubricating camshaft, valves, tappets.

Principle of adjustment of the "spring and ball" valve; the ball is placed in the path of oil line with a spring tension behind it. When pressure of oil circulation is reached, to which spring tension is adjusted, the ball is forced open and oil overflows past hole; in this instance, to the chain sprocket. In other words it is merely a "relief-valve." (see page 200.)

CHART NO. 99A—Example of Two Modern Engine Lubrication Systems: The "Circulating Splash" (Hudson as example) and the "Full Forced Feed" System (King).

***Note** the "eccentric" movement of cam for adjusting the pressure on the Hudson, and the **"ball and spring valve"** on the King. **Also see page 694. for Adjusting Hudson Oiling System.**

The depth of oil in splash systems should be just enough so that the splash will distribute the oil.

*Full Force Lubrication System.

Oil is forced by a pump from an oil reservoir, usually integral to bottom of the crank case, called the "oil pan." The oil is forced to the main bearings, thence to the connecting rod bearings and on up channels or pipes to the wrist pin; out the wrist pin to walls of cylinders.

Note the dotted lines showing the path of the oil. (A) is the oil reservoir. (B), piston or gear type of pump, (C), eccentric or gear for operating pump. (G), gauge placed on dash to indicate the pressure. (F), check valve. (D) is a strainer. Note in this system splash is not used. This would be termed a true circulating system of the forced feed type.

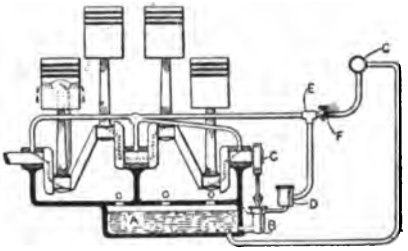


Fig. 4.—Diagram of "Forced Lubrication" system.

Oil Pump and Oil Pressure Gauge.

The Oil Pump.

There are two types of oil circulating pumps in general use. The gear type, fig. 1 and the plunger or piston type, fig. 2.

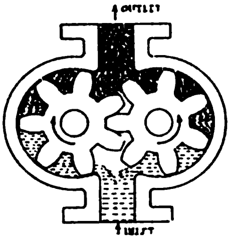


Fig. 1.

The gear type (fig. 1) can be operated by chain, but is usually operated by a shaft, through bevel or spiral gears, as per fig. 6, page 197.

The plunger type (fig. 2) is usually driven from the cam shaft, by an eccentric, and on marine engines instead of utilizing the cam shaft, the pump is sometimes driven from the crank shaft, fig. 4.

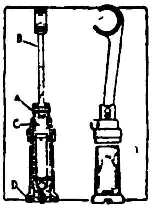


Fig. 2.

The adjustment of this type pump is made by screwing the plunger-rod (C) in—(this shortens the stroke); or out—which lengthens the stroke). This lengthening or shortening of the stroke, has the effect of regulating the flow of oil. The longer the stroke, the more oil flows and vice versa.

A modification of this type is shown in fig. 1, page 198 — note the plunger is shorter and is operated by a cam or eccentric movement. The cam forces the plunger in and a spring forces it out again, thus creating a suction effect which draws the oil from the lower reservoir.

*Oil Pressure and Gauge.

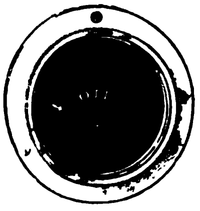


FIG 2. OIL PRESSURE GAUGE

This is a gauge placed on the dash board (see page 188), which shows the oil pressure. The normal on the Packard is 20 to 30 lbs. at 1000 r. p. m., engine hot. On the King, 15 to 20, on the Pierce-Arrow, 3 to 4 lbs. at lowest speed — to 35 lbs. at highest speed (50 m. p. h.); Cadillac, 5 to 7 lbs. when idling.

If the indicator needle on gauge drops to zero, it indicates oil level is low or for some reason oil is not circulating. In cold weather it may be an indication, that the cold test of the oil you are using is not sufficiently low and that the oil has congealed to a point where the pump cannot draw it from the oil pan. Do not under any consideration continue to run the engine if the hand on the cowl board vibrates or returns to zero or if it remains at zero after starting the engine.

The amount of pressure varies with the speed, temperature and viscosity or thickness of oil.

When the engine is cold, the pressure will be higher until the oil thins down. An excessive pressure on the gauge may also indicate the clogging of the system.

In other words, maximum pressures will be indicated at given speeds when the engine is cold and the oil is fresh; minimum pressures, when the engine is hot and the oil becomes thin.

Practically all engine lubricating oils become less viscous from use even under normal conditions. Running the engine too long with the "choker" control lever pulled back will cause the oil to be thinned more rapidly, due to the condensation of gasoline from the rich mixture. See page 205.

Too high a pressure will cause abnormal oil consumption. This should be adjusted according to the pressure recommended by the manufacturers (see page 542). **Always adjust when** engine is hot.

Regulation of Oil Pressure.

There are two general methods; (1) by an "eccentric" movement as per fig. 1, chart 99A, and by the adjustment of a "spring and ball" valve as per fig. 4, chart 99A.

If gauge does not show pressure: Make sure that the oil pan contains plenty of oil, as shown by oil level indicator. Should this show "full," remove priming plug on top of the pump and start engine. If oil flows from this, the pump is working and the trouble is with the gauge.

---

*See "Standard Adjustments of Leading Cars," page 542, for oil pressure for various cars.

Priming the pump: In case you think that the pump is clogged it is a good plan before taking it down to try priming it with the same kind of oil that you put in the crank case. To prime the pump, remove the plug, pour in oil until it fills, replace the plug and start engine. If priming does no good then it will be necessary to clean the pipes in order to find the obstruction. It is also advisable to occasionally clean the oil strainer.

When the pump is taken down it must be primed with oil, after replacing

†**Should at any time the oil gauge show full pressure when running at a slow speed,** foreign matter has become lodged in your distributor pipe, and you will have to proced as follows:

Take off oil pan, remove oil pump by removing cap screws which are usually accessible through the holes in the clutch cone and flywheel. The distributor pipe may then be drawn back through the opening left by the pump, and it should then be blown out with air pressure.

If the system is a splash system as well as a forced circulating system, it is possible to drive in, but be sure there is plenty of oil in pan.

†**Sometimes high gauge pressure** is due to cold weather and heavy congealed oil. If after engine is warmed up the pressure is excessive and the regulation does not vary it, then it can be attributed to clogged pipes.

Example of Modern "Circulating Splash" System—See chart 99A.

A modern engine lubrication system combining the splash and pump circulating system is shown in illustration figs. 1, 2, 3—used on the **Hudson super six.**

Oil pump; plunger type, mounted at front of engine and driven by a vertical shaft from crankshaft.

Regulation of oil pressure is governed by the speed of engine. An "**eccentric**" (E) is connected with the carburetor throttle. This keeps the cam from operating on the plunger: should the regulation be set so oil gauge registers 1 to 1½ degrees of pressure when engine is running slowly. By this we mean at speeds from 10 to 20 miles an hour. (see also page 694.)

As the throttle is opened, the eccentric is turned away from the plunger so as to allow it a greater amount of travel from the cam action. When the throttle is wide open, the eccentric should be in such a position as to permit a full travel of the pump plunger. By this adjustment, the oil pressure shown on the gauge will gradually increase as the car speed increases. It should register 3 to 4 degrees at 30 miles, per hour.

If gauge does not show this amount as above, the pump mechanism should be investigated. Upon indication of a pump being inoperative or gauge needle shows no movement, make sure there is plenty of oil in reservoir and engine is getting lubrication by splash, **and run** irrespective of the pump, then you can drive in carefully and have the system examined.

The oil reservoir on the Hudson contains over 8 gallons of oil in the troughs and in the reservoir itself. It is fitted with a float indicator which shows the level of the oil by means of a red button working in a glass tube. This is on the left-hand side of the engine. See fig. 2, chart 99A.

Example of a Modern "Full Forced Feed" System—See chart 99A.

The principle of operation, is explained in lower illustration in chart 99A and the text pertaining thereto refers to the King car.

The pressure regulation which differs from the Hudson is explained below.

Oil pressure regulation: The pressure of the oil in this full force system is controlled by a "**spring and ball**" valve located on the front right-hand side of the crankcase. The valve is provided with an adjustment which should not be tampered with unless the pressure drops below 5 lbs. or raises above 20 pounds, when the engine is speeding up.

To regulate, loosen lock nut and turn pressure regulating screw to the **right to increase the pressure,** and to the **left to decrease** it—see page 198. (see page 542 for pressure regulation different cars.)

Over lubrication: If the oil pan at any time contains more than *seven quarts of oil, the connecting rods will dip and thus create a splash which will over oil the pistons and cylinders, more on the right-hand block than the left, causing smoke to issue from the muffler pipe.

If the engine smokes, drain oil pan and measure its contents, as the oil level gauge may be stuck. If the oil pan does not contain more than the right amount, the oil is probably pumping past the pistons, due to worn or stuck piston rings. If this is the cause, new rings should be fitted at once.

Also remember that the use of too light a grade of cylinder oil is apt to cause engine to smoke. (The King Co. recommend "Mobiloil Gargoyle A.") Always clean screen and oil pan, washing with kerosene after draining dirty oil. (See "cleaning crank case," page 201.)

**The Kind of Lubricating Oil to Use.

At the present time most lubricating oils are straight **mineral** oils made from different distillates of petroleum.

A good high grade gas engine oil is necessary because the heat inside of an internal combustion type of engine will burn the oil, leaving nothing for lubrication—hence wear. Therefore nothing but a high grade oil will answer, one which **will stand up under** high †temperature of the cylinders **without** thinning down.

Another point to consider; if rings are tight and compression is good, then it is possible to use a light weight oil so it will splash readily. A light weight oil, under heat, can hold its body and will lubricate

---

**The chart of automobile recommendations, issued annually by the Vacuum Oil Co., Rochester, N. Y., specifies the correct grade of oil for each car and model for the last five years. It is free.

*Amount varies on different cars. This is for King, model E. †Studebaker instructions.

†Maximum temperature in cylinders, at top of explosion stroke is approximately 2700° F.; the minimum temperature during suction stroke, about 250° F.; average temperature during the four strokes, about 950° F. These are temperatures in the cylinders to which the outer side of oil film is exposed to.

Just the same as good heavy oil—if it is of the proper quality.

Some engines require a light bodied oil, others a heavy oil: Sometimes the heavy bodied oil may appear to hold its body or consistency but under heat it will thin down considerably whereas a light bodied oil will hold its consistency equally as well.

Note—any oil, no matter how thick or heavy, will thin down to a certain extent when heated.

Where multiple disk clutches are used which run in oil it is very important that a light bodied oil be used, else the plates will have a tendency to drag by **sticking together.**

If piston rings leak, which naturally lowers compression, then too light an oil will pass into the combustion chamber where the fire and flame will rapidly turn it to carbon, causing this carbon to stick to the valves, combustion-chamber and spark plug. Consequent result is loss of oil, fouled spark plugs and carbon deposit.

The proper oil to use is generally recommended by the maker of a car. The object has been to secure an oil that leaves no carbon deposit and that at the same time gives uniform complete lubrication. It must hold its body and form a **lasting film** on the wearing surfaces. If it thins down too much, it will leave the bearing without lubrication (see also, page 205, bottom).

A difference in oils is shown by their "flash points" and "burning points." When a lubricating oil is heated to a certain point, it will give off a thin smoke, if a lighted match is touched to it, the smoke will take fire with a quick flash. This is called the "flash point.**" On heating the oil still more, the oil itself will finally take fire and burn, and the temperature that will permit this is called the "**burning point.**" The flash and burning points are much higher in some oils than in others.

If oil with a low burning point is used in the cylinder of a gasoline engine, the intense heat will burn it before it can lubricate the cylinder walls and piston. **If oil of a sufficiently high burning point is used,** the temperature of the cylinder will not be high enough to burn it, and the cylinder walls and piston will be properly lubricated.

One simple method of testing—drain oil which has been used in engine, into a long narrow tube—let it stand 24 hours. If good oil it will show a small amount of black sediment at bottom; but floating above it, the sediment is red in color (by transmitted light).

Let a poor oil be tested, which is used under same conditions. At the end of a few minutes it will turn to a dense black. After standing 24 hours it will show a voluminous black sediment several times greater than that of good oil.

Black sediment indicates sulphur compounds in the oil. Sulphur is injurious to bearings due to lack of lubricating qualities; also pits the valves causing leakage of compression.

Using Oil Over Again, Adding Fresh Oil, Cleaning Crank Case, Etc.

Using cylinder oil over again. The cylinder oil which is drained from the crank case of an engine having a circulating system, after every 1000 miles of use, may be used, for the gear set if it is strained through a filter, and is good oil to begin with.

It is then mixed with grease. The oil is merely charred and is slightly stringy from the wax which has been formed in it. This wax-like consistency is the very qualification necessary for a gear lubricant in that it holds the oil to the gear. The oil should be drained in a pan, mixed with grease until the mass assumes the consistency of the regular transmission lubricant familiar to all automobilists, being neither liquid nor solid.

Adding Fresh Oil.

It is important to note that fresh oil of another make should not be added to the oil pan before thoroughly washing out the old oil. Clean, good oil put into a dirty engine with gummed-up bearings has simply no chance of asserting its superiority under the unfavorable circumstances. It has first of all to get rid of the gumming round the bearings before its lubricating qualities will be manifested.

*Cleaning Crank Case.

The system should be drained every thousand miles by removing the plug in the bottom of the oil pan. After the dirty oil is drained off, the plug should be replaced and about one gallon of kerosene poured into the oil pan through the filler tube. With ignition switch "off" so the engine will not start, press in on the starter button and allow the starting motor to crank the engine for about one minute.

Also step on the running board and rock the car back and forth. This will allow the kerosene to wash the interior of the engine thoroughly. Remove the drain plug again and drain off all the kerosene. Clean strainer.

It is very important that the kerosene be entirely drained, for if left in engine it will thin the fresh oil and cause it to lose its lubricating qualities.

The engine will probably smoke more or less and there may be missing, due to the kerosene, but after running engine for a while the smoke ought to pass away and the spark plug can then be cleaned and properly set.

Do not start engine under its own power even after new oil has been put in, until first turning it over several times with starter, this is done to eliminate all kerosene from engine distributor pipe and bearings. This action pumps the engine oil in its proper channels before it is run on its own power.

A "scored" cylinder, means there are scratches or cuts in the cylinder caused by lack of oil. "**Burnt" bearings on a crank-shaft or elsewhere,** means the bearing is cut, caused by friction from lack of oil.

Engine Lubrication Troubles.

Cause—too much oil: Oil pan too full; oil pressure adjustment too high.

Effect—too much oil: Smoking at exhaust; carbon in cylinders; pre-ignition and knocking; carbon on valves necessitating grinding; spark plugs become fouled.

Cause—not enough oil: Oil level in oil pan too low; oil pressure improperly adjusted; oil pipes clogged; pump not operating.

Effect—not enough oil: Overheating; seized bearings or pistons; scored or cut cylinders; knocking.

***Manufacturers advise that oil pan be cleaned frequently,** especially during cold weather—due to more raw gasoline being drawn into cylinder and not being combusted—see page 205, bottom.

†Cooling the lubricating oil; on some racing cars and high speed marine and aeronautical engines of high compression and speed, the oil is cooled by leading the oil out of the engine base, where temperature can be lowered, before pumping it back into engine. Castor oil is also used, page 918.

**Another test is the cold test—not to be over 25° F.

Results of Not Using Enough Oil or Too Much.

If the engine is not getting enough oil, the cylinder will become so hot that any oil that may have splashed on its outside will be burned—the smell being an indication of the condition. Further running without oil will produce a hard metallic knock, and the heat will finally cause the piston to stick in the cylinder.

An engine that is run without oil will be ruined, for the piston rings and the walls will be cut and scratched lengthwise, (called "scored") so that the compression will not hold.

If the piston sticks or "seizes" and pounds from lack of oil, stop—wait until it cools and then fill the crank case to pet cock level—also fill radiator with water **after engine has cooled sufficiently.**

The engine should then be thoroughly inspected before driving, to see if any damage has been done. If no obvious damage has been done, a thorough examination should be carried on to determine whether or not the running without oil has burned the bearings or caused other trouble. This can be ascertained by starting the engine, and if it pounds or knocks it is a certain indication of bearings burned or cylinders scored.

A new bearing, or any other new part that has not worn smooth, requires more oil than one that has been run. It is always better to give a bearing too much oil than too little, but the exact amount of oil required for each part of the car should be learned as quickly as possible, in order to prevent waste.

Results of Using Too Much Oil.

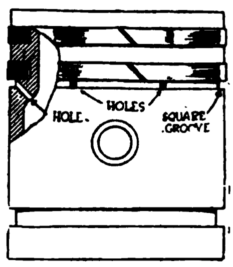
The only place where too much oil is harmful in an engine is in the cylinders, where it is burnt with an excessive precipitation of carbon that adheres to the piston and cylinder heads, lodges on the valve-seats causing pre-ignition, overheating and knocking, loss of compression, and passes off into the muffler, clogging it, giving off much objectionable smoke, and ultimately reducing the efficiency of the muffler to such an extent that the back-pressure causes a noticeable loss of power.

The local remedy for these is to scrape and cleanse the cylinders, grind the valves, clean the muffler, and then find the cause of the excessive oil supply and cut it down.

Too much oil in a circulating system in which the oil is simply drawn from the reservoir and forced into the splash compartments of the crank chamber, is caused only from an excessive supply in the reservoir, of improper design.

The oil pressure to be maintained on various cars shown under "Standard Adjustments of Leading Cars"—chart 228.

****Prevention of over-oiling:** Carbonization, sooty spark plugs and a smoky exhaust are due to the fact that the oil works up past the piston into the combustion chamber. The illustration shows a simple but effective method of supplying a return for this excess oil to the crank case. The piston is removed, chucked in a lathe, and a groove 1/16 in. square cut in the outside edge of the ring groove just above the wrist pin. †Six 1/16-in. holes are then drilled through the piston at regular intervals and are inclined toward the wrist pin at an angle of about 45 deg. The oil is caught in the groove and thrown downward onto the wrist pin, not only removing the excess oil from the cylinder but also effectively lubricating the wrist pin.



If the piston rings leak, the oil passes around the rings, out the exhaust, causing considerable smoke. Another indication of leaking rings is the constant oil soaked spark plugs. Therefore it would appear if **the rings are not in the best condition** it would then be a wise thing to use heavier oil or fit new rings.

*Carbon.

The cause of carbon deposit is due to; (1) amount and grade of oil (2) the carburetion mixture.

If too much gasoline is used it will cause carbon deposit just the same as a poor grade of oil.

Excessive heat will also cause carbon, as oil vaporizes.

Because oil becomes more fluid when it is heated, the oil feeds should be adjusted after the engine has been running, for if adjustments are made for cold oils the flow will be much more rapid when it is warmed, and the bearings will be flooded, and the excess oil will pass by the rings causing carbon deposits.

**Smoky Exhaust—Cause of

If the vapor is black and foul smelling it is caused by too "rich a mixture" (too much gasoline); this can be remedied in carburetor adjustment.

If the smoke is white or blue, the engine is supplied with an excess of oil.

If the smoke is grey, there is too much fuel as well as lubricating oil.

The reason an engine excessively supplied with oil smokes is that there is too much in the crank case; the entire lower portion of connecting rod will dip into it and the lubricant will be forced into the cylinder to work by the rings on the piston, then into the combustion chamber, thence out the exhaust.

---

*See page 623: "Relation of Carbon to Lubricating Oil," and page 735. †Oldsmobile advise 5/32" holes. **See also pages 652 and 793.

Depending upon smoke issuing from the exhaust pipe of a car as a means of testing whether or not the cylinder lubrication is sufficient or over-sufficient is by no means conclusive. The fact that the exhaust is smoky does not indicate that lubrication is complete, or excessive in all cylinders. If it issues in a steady and continuous stream probably there is sufficient oil in the engine and probably, too much, but if it comes in intermittent puffs, it may be inferred that one compartment only of the crank case is flooded.

Leaky piston rings are quite frequently the cause of excessive smoke—see repair subject, "leaky piston rings."

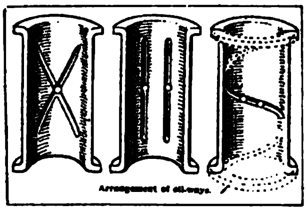
Oil Drips.

The average oil drips come from the cap screws being loose on crankcase. Other drips come from bearings and quite frequently from the plungers or tappets above the cam shaft.

On some cars the fan often picks up the oil oozing from bearings and throws it over the inside of hood.

**Oil Grooves in Bearings.

The old-fashioned arrangement of two simple holes on the upper side leading into oil-way either straight, starred, or spiral, appears to be as good as any.


Arrangement of oil-ways.

But, be it noted, the oil-ways should not be cut to the extreme edge of the bush, or their action as reservoirs is apt to be interfered with.

Similarly the bevelling of the edges of the bush should likewise be discontinued before reaching the outside. The arrangements of oil-ways is shown in illustration. (see also page 644.)

***"Running-in" a New Engine.

Fine grooves (not visible to the eye) are left on piston by the cutting point of the lathe tool when originally made. Also **pear shaped pits** are left by grinding machine on **cylinder walls.** When engine is new the projections are in the fine line stage.

At ordinary temperature, say, .0035 piston clearance, will permit the projections to pass one another. When temperature of engine is raised the projections will touch from expansion and if speed is excessive the temperature is raised which increases expansion and friction takes place and the projections imbed themselves in the recesses opposite them, which will cause a stuck or "seized" piston (see page 639) with the attendant condition of a "scored" or cut cylinder wall (see pages 201, 653).

Care is necessary to use plenty of oil and run at normal rates of speed until the projections gradually change shape, and are bent over in such a way that the high points fill the recesses.

After engine has been run a 1000 miles with care the piston and cylinder surfaces become very smooth and polished. (see also pages 489 and 651, why "**piston clearance**" is necessary.)

†Pointers on General Lubrication of the Car.

It is a difficult matter to advise just what lubricants to use on all cars, as different manufacturers advise what to use and their advice ought to be followed. However, as an example, the average is given on page 204, Studebaker and Hudson.

A few pointers on lubricating the different parts will be given in the lines following:

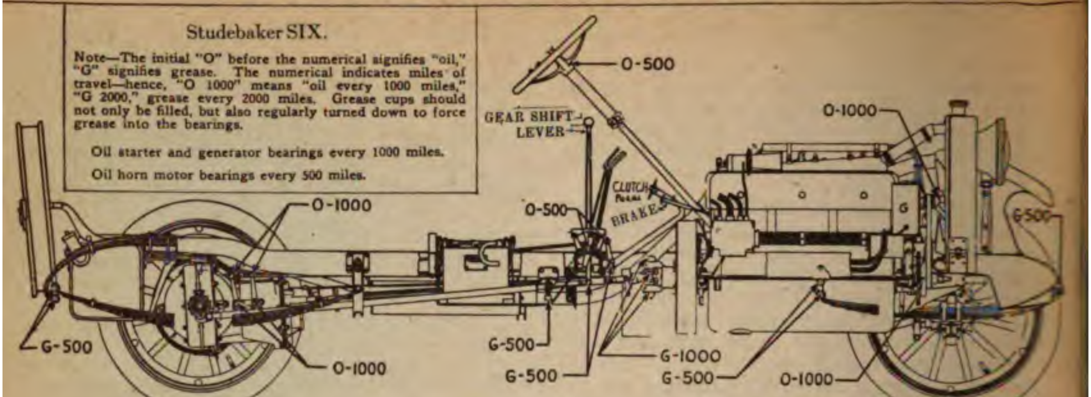
Disk clutch: There is much misinformation about the caring for and lubrication of a disk clutch. Heavy oil often is put into such a mechanism with rather disastrous results. At the end of a reasonable distance, say 500 miles, the old oil in a disk clutch should be removed. There is usually a drain plug fitted to the clutch housing and this should be removed to let the oil out, after which the clutch should be rinsed with kerosene, and again allowed to drain completely. Thus cleaned, a supply of a light clutch oil should be put in until the level is about even with the bottom of the clutch shaft. This allows the plates to pass through a bath of oil, and is the desirable condition. Some recommend a mixture of a **light oil with kerosene**, but as the proportion varies, it is best to purchase a regular light clutch oil. The foregoing does not apply to dry disk clutches.

The transmission: It is important in lubricating the gear set that the oil or grease should not be too heavy, for in that case it will stick to the gears and be thrown from them by centrifugal force against the sides of the gearcase. This happens for the first few minutes, but after the mechanism has been in operation for some time, all of such solid lubricant has been picked up by the rapidly rotating parts and thrown from them. Very soon, they are free of the very lubricant they have been acting upon and soon run hot. The best lubricant is a **heavy oil that will run, or a grease of such consistency that it will flow.** Thus, when the gears and shafts pass through it, it does not adhere to them, and there is not the tendency to throw it out of contact with the bearing surfaces. There are many special forms of gearset and differential semi-fluid greases and heavy oils on the market and the makers have studied these facts so that the products perform their function of be-

---

**See page 644. †See pages 621, 622. ***See also pages 489 and 507.

***When engine stands over night, don't immediately race engine to warm it up, because the oil has drained from bearings, cylinder walls, etc. Consequently it's going to take a few minutes to lubricate these parts properly. Therefore first let it run slowly for a minute or so.

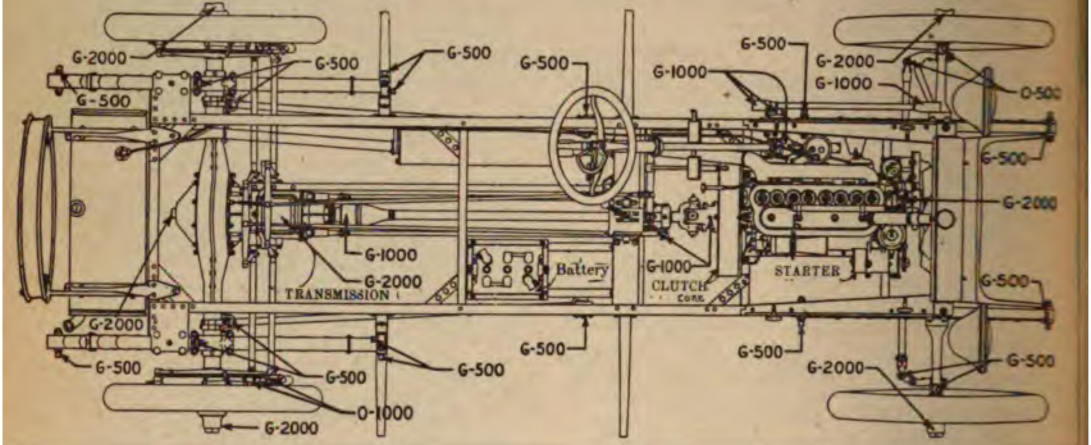


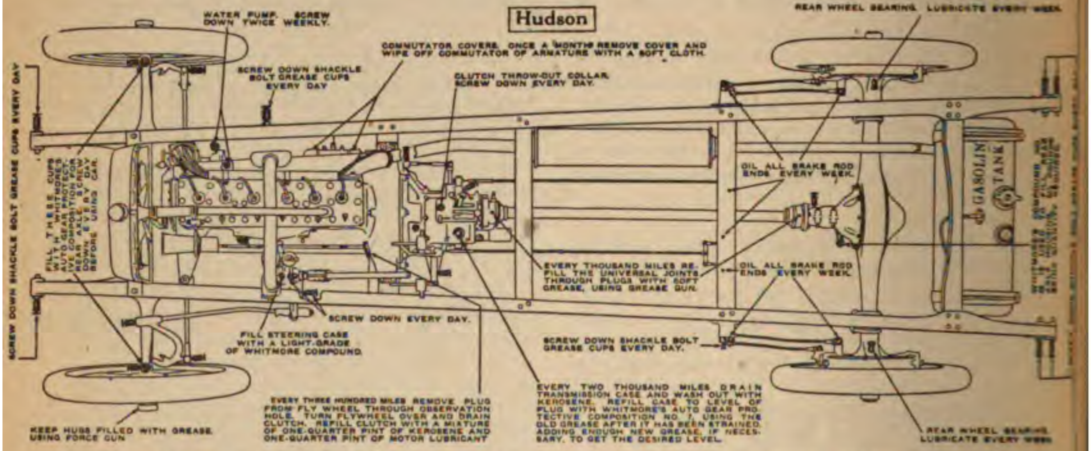
Studebaker SIX.

Note—The initial "O" before the numerical signifies "oil," "G" signifies grease. The numerical indicates miles of travel—hence, "O 1000" means "oil every 1000 miles," "G 2000," grease every 2000 miles. Grease cups should not only be filled, but also regularly turned down to force grease into the bearings.

Oil starter and generator bearings every 1000 miles.

Oil horn motor bearings every 500 miles.





Hudson
WATER PUMP. SCREW DOWN TWICE WEEKLY.
COMMUTATOR COVERS. ONCE A MONTH REMOVE COVER AND WIPE OFF COMMUTATOR OF ARMATURE WITH A SOFT CLOTH.
REAR WHEEL BEARING. LUBRICATE EVERY WEEK.
SCREW DOWN SHACKLE BOLT GREASE CUPS EVERY DAY
CLUTCH THROW-OUT COLLAR. SCREW DOWN EVERY DAY.
SCREW DOWN SHACKLE BOLT GREASE CUPS EVERY DAY
FILL THESE CUPS WITH WHITMORE'S AUTO GEAR PROTECTIVE COMPOSITION FOR REAR AXLE. SCREW DOWN EVERY DAY BEFORE USING CAR.
OIL ALL BRAKE ROD ENDS EVERY WEEK.
GASOLINE TANK
EVERY THOUSAND MILES REFILL THE UNIVERSAL JOINTS THROUGH PLUGS WITH SOFT GREASE, USING GREASE GUN.
OIL ALL BRAKE ROD ENDS EVERY WEEK.
SCREW DOWN EVERY DAY.
FILL STEERING CASE WITH A LIGHT-GRADE OF WHITMORE COMPOUND.
SCREW DOWN SHACKLE BOLT GREASE CUPS EVERY DAY.
KEEP HUBS FILLED WITH GREASE. USING FORCE GUN
EVERY THREE HUNDRED MILES REMOVE PLUG FROM FLY WHEEL THROUGH OBSERVATION HOLE. TURN FLYWHEEL OVER AND DRAIN CLUTCH. REFILL CLUTCH WITH A MIXTURE OF ONE-QUARTER PINT OF KEROSENE AND ONE-QUARTER PINT OF MOTOR LUBRICANT
EVERY TWO THOUSAND MILES DRAIN TRANSMISSION CASE AND WASH OUT WITH KEROSENE. REFILL CASE TO LEVEL OF PLUG WITH WHITMORE'S AUTO GEAR PROTECTIVE COMPOSITION NO. 7, USING THE OLD GREASE AFTER IT HAS BEEN STRAINED, ADDING ENOUGH NEW GREASE, IF NECESSARY, TO GET THE DESIRED LEVEL.
REAR WHEEL BEARING. LUBRICATE EVERY WEEK.

NOTE:—Every fifteen hundred miles, drain all oil from the motor by removing the plug at the bottom of the oil reservoir. Pour kerosene into the crank case through the filler on left side of motor, and turn the motor over with electric starter for a minute. Stop motor. Drain out kerosene and add fresh motor oil until the oil indicator on the left side of motor shows "FULL." This should require approximately 3 gallons. Once a week when the car is laid up for the night, and while the motor is still hot, pour in each priming cock abous three teaspoonfuls of kerosene, close them and let stand all night. In the morning start the motor in the usual manner.

Studebaker Four and Six: Engine lubrication is the "circulating splash" system with a gear pump. To drain and clean oil reservoir of engine: At the bottom of the oil pan is a large plug which can be taken out for cleaning purposes. After all old oil has run from this plug, pour one gallon of kerosene oil through the breather pipe, which will flood out all dirt and sediment which may have collected at the bottom of pan. The reservoir should then be filled with clean oil. When properly filled, the FOUR holds one and one-half gallons of oil and the SIX holds two and one-half gallons. Parts to lubricate are explained above. Note the transmission is at the rear of drive shaft attached to the axle housing.

Hudson super-six: Engine lubrication is the "circulation splash" system as described on page 198. Parts to lubricate are explained above. Note the transmission and clutch are a unit with the engine.

HART NO. 100—Parts to Lubricate on a Modern Car: Studebaker Six and Hudson Super Six.

he above Studebaker is the 1917 "six." The 1918 model has transmission set forward, instead of rear as own above.

ing just light enough to prevent sticking to the revolving parts. It is obviously wrong, therefore, to put any common grease into a gearset, for it not only acts as above, but has not the ability to get into bearings like a fluid material.

In filling the gearset, put in the lubricant to a depth about half the height of the gearbox. That is, have it come about **even with the center of the main shaft,** this will completely submerge the counter-shaft in the average gearset design and will bring the under face of the main shaft gears into the lubricant. It is important in this connection to see that the packing rings are tight and prevent leakage where the drive shaft emerges from the gearcase and where the shaft from the clutch enters it. If there is leakage here, it not only will act as a collector of dirt and dust, but the gears will be robbed of their proper lubrication.

The differential housing should hold the lubricant in the rear axle gears, so that attention is needed only as stated above but sometimes a disagreeable looking rear axle is noticed where the oil or grease oozes out through cracks or leaks in the rear cover plate or through the axle tubes onto the wheels. This is not so common a fault as it used to be when axles were not designed so well to trap the oil and keep it where it belongs. However, an occasional careless driver will let his axle get in this condition by not having a proper gasket between the differential housing cover plate and the housing itself. It is not much trouble to cut a gasket if the old one gets worn or out of shape, and it **saves the brake bands which often become oil soaked and slip.**

†The axle: In some cases, a heavy transmission oil is recommended for the axle but in most instances it is best to use either a sem-fluid grease or even a heavy grease. There is less chance for the gears to throw these, and the space is smaller so that it is next to impossible for the grease to get away from the lubricating points. It is next to impossible to give any fixed rule for rear axle lubrication. There are so many designs, and where a heavy oil or a grease will work satisfactorily in one instance, some other form is better in another.

Dodge for instance uses 600W—steam cylinder oil two parts, and one part medium grease.

*The Use of Graphite in the Automobile Engine.

The use of flake motor graphite mixed with cylinder lubricating oil when properly used will improve compression, decrease the amount of oil required, fill up scores in the cylinder walls, prevent valves and rings sticking and thereby cure smoky exhaust.

A great deal of prejudice has existed against graphite lubrication due to ignorance. When automobiles first came on the market, chauffeurs would go to a hardware store to buy graphite to mix with their grease and would get Dixon's Flake Graphite No. 1 which is intended for lubrication of steam cylinders and other heavy work. Then they would use about five times too much of it and trouble would result. Of course, graphite was blamed. However, anyone who has ever taken the trouble to investigate Dixon graphite automobile lubricants has seen the sense of their claims and would use no other kind of lubrication. It stands to reason that when bearings and gear teeth are polished with fine flake graphite that there are actually no metallic surfaces in contact and hence there can be no wear, no heating and practically no friction.

However, assuming that graphite is an ideal lubricant certain requirements are necessary, for instance:

For splash oiling system, the Dixon Co. recommend adding a scant teaspoonful of motor graphite to each quart of oil in the crank case and then add another teaspoonful at the end of each one thousand miles. The graphite may be mixed with a little oil and poured down the breather. You will notice that this is a very small amount of graphite but it is all that is required.

For force feed system it is not advisable to mix the graphite with the oil on account of the possibility of clogging some of the small passages.

A small amount of dry graphite may be placed on the hand and permitted to be inhaled through the air intake of the carburetor directly to the cylinders. This should be done about once a week when your car is in ordinary service.

More graphite can be used when it is introduced in the dry form because part of it is immediately blown out through the exhaust.

On account of the location of the magneto on Ford cars and the possibility of short circuiting it we do not recommend the use of graphite in the crank case or transmission case of these cars. This is merely a precaution that we take, although we know of many Ford owners who use graphite in their engines with entire satisfaction.

How Unvaporized Gasoline Thins The Oil.

Gasoline vapor that is not completely consumed in the engine does one of three things; it either passes out into the exhaust in an unburned state and is wasted, is deposited in the form of carbon within the cylinder, or condenses and runs down past pistons into the crankcase.

The first of these is the most direct loss, but the other two are equally important in the long run. A carbonised engine is of itself inefficient. **Carbon makes the engine miss, makes it overheat and pre-ignite. All of these things are sure to shorten the life of the engine. When the unburned fuel runs down past the piston it destroys the seal between piston rings and cylinder, removes the oil which is to protect the surface of the cylinder and piston from friction and wear and, lastly dilutes the lubricating oil in the crankcase to such an extent that in time it becomes worthless.

Manufacturers are advising now that the crankcase be drained even more frequently than ever before for this very reason. As cold weather approaches, the necessity for frequently refilling completely with new oil will become more imperative. Either the motorist is forced to drain out his oil and refill with fresh at an increased outlay or he must suffer the consequences of an engine damaged by insufficient lubrication.

**See page 628. †Grease working out axle ends on brake bands—cause brakes to slip.

*A free booklet, advising just where graphite as a lubricant can be used on a motor car and the kind to use, can be obtained by writing the Joseph Dixon Crucible Co., Jersey City, N. J. The writer knowing the importance of good lubricant, recommends the use of graphite. The Woolf Graphite Lubricator Co., Omaha, Neb., market a device for injecting graphite into intake manifolds of engines.

INSTRUCTION No. 16.

IGNITION: LOW TENSION COIL. Purpose. Brief Explanation of Electricity. How Electricity is Produced. Methods of Generating Electricity. Low Tension "Make and Break" Ignition—using a Low Tension Coil.

Principle of Ignition.

There are three things required before a gasoline engine will run. These three things are absolutely essential. **First**, it is necessary to have a mixture of gasoline and air in the engine cylinders. **Second**, this mixture must be compressed, and third, there must be a spark to set fire to the compressed mixture. The **third** thing required to make the engine run is the one which is most difficult to understand, if the reader is not familiar with electricity. The system of ignition, as it is called, is usually made up of certain electrical devices which probably give more trouble to the motorist than all the other mechanisms on the machine.

In order that you may thoroughly understand the principles upon which the various ignition systems are built up, and how these systems are operated and maintained, it is well to start at the beginning.

The original and first method for igniting the gas in a gasoline engine was by the means of a "hot tube" or flame, but this method now being obsolete, we will deal only with the electric ignition.

The ignition systems used on automobile engines at the present time are all electrical systems giving an electric spark which passes in the cylinder of the engine and sets fire to the compressed mixture, and as you will be dealing with electricity and electrical apparatus in these systems, the first thing to know is how electricity acts and how you can make it do work for you.

What is Electricity?

No one can tell you just what electricity is; we know how it acts and how it moves in the same way that we know how the force of gravity acts.

If you throw a stone into the air it will come down again, but you cannot explain why, beyond saying that the force of gravity makes it come down. You cannot say just what "gravity" is—so it is with electricity.

Electricity is in everything—in your body, in your clothes, in the magazine you are reading, in the chair upon which you are sitting—and the only reason you do not feel a shock is because the electricity is not in "motion."

If you put a water wheel in the middle of a pond, the wheel will not revolve, no matter how deep or how large the pond may be.

To make the wheel revolve to get any work out of it, you must place the wheel in position that the water may flow from a high level to a low level, and in flowing, move or push the wheel around.

There must be a current of water before the wheel will move—so in electricity—there must be a "current or a flowing of electricity" before you can get any work out of it.

If you want water to flow, you provide a path for it downhill, or, in other words, you allow it to take a natural course from a high level to a low level.

You can pump water to a high level and then get it to flow through pipes or along a stream.

When water is pumped into a tank that is, say, 100 feet high, you know that there will be a certain pressure in the pipes leading from the tank, and if you want to know how much pressure there is, you will measure it in so many pounds pressure.

At the same time you can measure the quantity of water flowing out of the pipes, and you can say that so many gallons will flow in a minute.

You are no doubt perfectly familiar with the measurements called a pound, gallon and minute, and if you were told that 200 gallons of water were flowing out of a certain pipe in a minute at a pressure of 50 pounds, you would have a pretty good idea of the current of water referred to.

Now, when you come to work with electricity, you should be able to understand the current in the same way, but you will find that the measurements of electric currents are not stated in gallons and pounds, but in other terms, as, **amperes**, meaning the **quantity** of current flowing; **volts**, meaning the **pressure**, causing it to flow; and **ohms**, meaning the **resistance** offered to the flow of current.

How Electricity is Transmitted.

Electricity produced in one place may be transmitted to another place, provided a path is arranged so that it may **return** to where it started. It will not flow if there is no circuit; that is, a continuous path.

If the circuit is broken, the flow will immediately stop, and will not start again until the circuit is once more completed.

Copper wire is usually used to take the electric current from where it is produced to the place where it is to be used, and another wire may be used to bring it back again, the first wire being called the "**lead**," and the second the "**return**."

If there is any way in which the current may leak from the *lead wire and return to the starting point without going through the entire circuit, it will do so, and this leakage is called a **short circuit** or **ground.**

****A conductor**: Anything that will permit a current of electricity to pass through it is called a **conductor**; all metals are conductors.

Insulators: Substances such as rubber, china, porcelain, glass, wood fibre and mica are called **non-conductors** or **insulators.**

A wire is insulated to prevent leakage of current into any metallic substance it may touch by wrapping it with cotton or silk, which is soaked with rubber' to prevent dampness from getting in.

When dry, cotton and silk are insulators, but as water is a conductor, damp cotton and silk cease to be insulators.

While all metals are conductors, some are better conductors than others; a copper wire, for instance, will pass a larger current than an iron wire of the same size. Due to the fact that copper has a lower resistance.

If a wire has more electricity passed through it than it can easily conduct, heat will be generated, and it may get so hot that it will melt.

The larger a wire is, the greater is the current that it can pass without heating. (voltage being the same.)

Copper is in most general use as a conductor of electricity, because of its low resistance: silver is a better conductor, as it has a still lower resistance, but is not used because of the expense.

Explanation of Voltage and Amperage. Also "Series," "Parallel" and "Multiple" Connections.

A current of electricity flowing in a wire may be measured just as a current of water flowing in a pipe may be measured.

The amount of water that flows through a pipe depends on the pressure, or head, and the friction in the pipe. The volume of electricity that flows through a wire depends on the pressure or voltage at which it flows and the ohmic resistance of the wire.

Volts (pressure). The quantity of water flowing through a pipe depends largely on the pressure. The amount of electricity flowing, or the strength of current in amperes depends in part on the pressure in volts. Thus the amount of current flowing is measured in amperes and the pressure causing it to flow is measured in **volts.** The **volt** is the practical unit of electromotive force.

The electro-motive force, usually written E. M. F., is the total force required to cause the current to flow through the entire circuit.

The unit of electromotive force is the volt.

Ampere (current) a current of water flowing in a pipe is measured in gallons per second or cubic feet per second. An electric current is measured in **amperes.** Thus we say the strength of one ampere flows for 60 seconds, then the total quantity is 60 ampere-seconds, or 60 coulombs of electricity.

The coulomb is the unit of quantity which equals the rate of flow X time, as ampere seconds. One **ampere hour** would equal 3600 coulombs. **The ampere,** therefore is the current strength, intensity of current or rate of flow, but in this instruction we have referred to the ampere as the **volume** or **quantity** of current flowing.

The velocity of electricity through a copper wire is said to be 288,000 miles per second.

An ohm is the unit of electric resistance. Such a resistance as would limit the flow of electricity under an electromotive force of one volt to a current of one ampere. For instance, we speak of a certain size of copper wire, a certain length having so many ohms resistance. Iron wire offers 6½ times more resistance to the flow of current, than the same length and size of copper wire, therefore if it is not of sufficient size to permit the free passage of current, the wire will heat.

The watt is the unit of electric power. 746 watts equal one horse power. Multiplying the amperes by the volts gives watts.

In order to explain the meaning of voltage and amperage more clearly, we will use a hydraulic analogy, which gives the explanation as follows:

Usually the ignition coil is so made it will work with a pressure of 6 volts. The resistance (see page 209 for meaning of this word) that the electricity meets in the wiring of the ignition system is so great that if we only had a pressure of 1 volt, this would not be sufficient to force enough current through the wires.† As the pressure increases the quantity of current that flows becomes greater. It has been found that a pressure of 6 volts is sufficient for most ignition systems which require from 1 to 5 amperes.

Series connection. The way we build the pressure up to 6 volts, with dry cells as an example, which give only 1¼ or 1½ volts each, is by connecting them in "series" as it is called.††

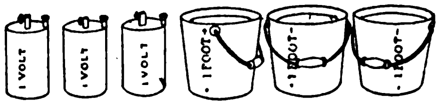


Fig. 1.—Comparing dry cells or storage battery cells with pails of water.

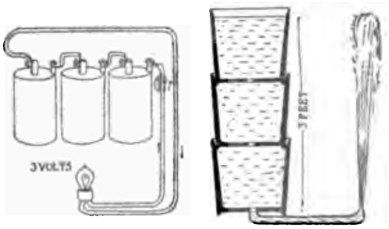


Fig. 2.—Dry cells connected in "series" similar to pails of water placed as shown.

---

*Pronounced leed, not lead. ****The best conductor** is silver, next best, copper, then aluminum, zinc, brass, platinum, iron, nickel, tin, lead, German silver, antimony, mercury, bismuth, carbon, water. Thus it will be seen that iron offers more resistance than copper, and carbon and water more resistance than iron. **Non-conductors** are slate, marble (if no metallic veins), oils, porcelain, **glass,** rubber, dry paper, silk, gutta percha, shellac, ebonite, etc. †See page 427, size wire to use.

††**Storage battery cells** give 2 volts, large or small. The pressure is built up by adding more cells in same manner.

This can be explained by referring to our hydraulic analogy, as follows: **Suppose we had three pails of water,** each of them 1 foot high, as shown in fig. 1, and suppose we had three dry cells, each of them giving a pressure of 1 volt, we will say for the sake of simplicity. If we would take these three pails and set them one on top of the other, and make an opening in the bottom of the three pails, connecting the opening in the bottom one with a pipe, the pressure in the pipe would be three times as great as if we had only one pail. That is, we would have a head of 3 feet of water in the pipe and the water would squirt up approximately 3 feet in the air, as in fig. 2.

When the cells are connected so that the pressures in them are added, it is called a "series" connection because it corresponds to putting the pails of water in a series one above the other. To make this connection, which is shown in fig. 2, we connect the positive terminal of one cell with the negative terminal of the next, the positive terminal of that one with the negative of the next, and so on. Finally, running one of the wires of the outside circuit, from a lamp in this case, to the negative terminal of one end cell and the other outside wire to the positive terminal of the other end cell. Since there is a pressure of 1 volt, we will say, between the positive and negative terminals of each cell, we have simply added the voltage of all the other cells to it, just as we added the pressure in the other pails of water to the first one when we set the others on top of it.

Series connection means that the carbon (positive pole) of one cell is connected to the zinc (negative pole) of the second; the carbon of the second to the zinc of the third and so on. This leaves the carbon of the last cell free to be connected with the outside circuit, likewise the zinc of the first cell. So, when the entire battery of cells flows from the outside carbon through the lamp or ignition coil, or whatever is in the outside circuit, and back to the battery through the zinc of the first cell.

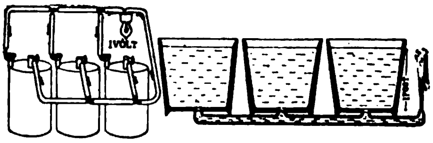


Fig. 3.—Dry cells connected in "parallel" or "multiple," similar to pails of water connected one with the other.

Parallel connection: There is another way in which we can attach the three pails of water to the pipe, and that is the arrangement shown in fig. 3. Instead of setting one pail on top of the other we have them all on the same level and if we connect the bottom of each one to the pipe the water will flow through the pipe, but **we will have only one foot of head** and the water will squirt only as high as the level of that in any one of the three pails, that is, the pressure would be no greater with the three pails connected this way than it is if there was only one pail connected with the pipe, but the water will flow three times as long.

We can do almost the same thing with the electricity in the three dry cells (or storage battery cells) as we did with the water in the pails, that is, we can connect them up so that the pressure of each of them is added to that of the rest, or we can connect them up so that the pressure of all three is equal only to that of one, and like the water, the current will flow 3 times as long.

This arrangement in fig. 3, is called the "parallel," or "multiple" arrangement, and corresponds to connecting the pails of water to a pipe when all of them are at the same level. When we connected the pails of water in this way we simply added to the capacity of one pail without increasing the head or pressure.

When we connected the three pails set on a level it was just as though we multiplied the size or capacity (amperage) of one pail by three.

In the multiple or parallel arrangement of a dry cell (or storage battery cells) we simply connect all the positive terminals, or plates, and all the negative terminals, or plates, together, and the effect is merely that of adding to the size of the plate or capacity of the cell. When we connect the three cells in multiple or parallel, as in fig. 3, we have multiplied the capacity (amperage) of the cell by three, but we did not increase the pressure.

If we increase the size of the plates in a cell we lengthen the time during which it will give a current of electricity.

If one dry cell will give 1 volt for one day, three dry cells would give 1 volt for three days if connected in multiple, but if connected in series, as shown in fig. 2, we would get 3 volts pressure, but the three cells would last only one day. This can be explained by considering the water pails again, with the pails one on top of the other, giving a 3-foot head, the water would run out in one-third the time that it would if the pails were connected together as at the right of fig. 3, where they get only 1-foot head. It will be seen that in series connecting we increase the voltage but leave the volume or amperage the same, and in parallel connection we increase the volume or amperage, but leave the pressure or voltage the same, and in both cases the watts will be equal.

In order, then, to get a pressure of 6 volts, with dry cells giving 1½ volts each, we simply need to connect four cells in series, for then we have four times 1½ or 6 volts, which is pressure enough for the ordinary ignition system.

As the voltage has a tendency to drop when in use, 6 cells are usually placed in series.

It is not well, however, to use more cells in series than are needed, for good working, because the excess of pressure would force the electricity through the circuit at too great a rate or amperage and this high current would damage the vibrators of the spark coils as will be explained later on.

With the four cells connected in series and the total giving 6 volts pressure, we have the life of only one cell, that is, the four cells connected this way will not last any longer approximately than if we had only one cell.

Multiple-series connection: We can double the life of the battery, thus obtained by connecting the four cells in series, simply by connecting up four more cells in series and then connecting the two sets of four cells each in "parallel or multiple." The arrangement is illustrated in fig. 4, in which case we have three of the 1-volt cells we speak of, connected in series and three more in series, with the free negative terminals of each set tied together and the free positive terminals of each set tied together.

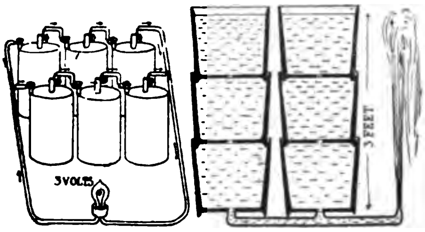


Fig. 4.—Two sets of cells connected in "parallel." Each set connected in "series;" called "multiple series." Note the comparison.

Here we have obtained a pressure of 3 volts by connecting three cells in series and have doubled the life or capacity (amperage) by connecting in parallel another three which have been connected with each other in series. The effect is just the same as if we had taken three cells of double the capacity (amperage) and connected them in series. We would accomplish the same result with water pails by making two piles of three each and connecting both to the same pipe, as indicated in fig. 4. Here we have obtained a head of 3 feet and doubled the capacity (amperage) of our source by doubling the amount of water.

In the cell parallel arrangement, illustrated in fig. 3, the current flows from the carbon of one end cell through the circuit and back to the battery through the zinc of the same cell, so that the current from the first cell does not have to flow through the second and third cells in order to go through the circuit and back to where it started, but is able to flow past them. The current from each of the three cells flows into the wire connecting their carbons and on its return flows back into the cell from the wire connecting their zincs. If you have a current of four amperes in the circuit, each cell will be giving one-third of the current, and only one-third of it will be flowing through any one cell. With two sets in multiple only half this amount of current will be flowing through each cell.

Separate sets if used for ignition: In a motor car where dry cells and vibrator coils are used for ignition it will be found necessary to use two sets of cells which are not connected to each other, but either one of which can be switched into the circuit if desired. In fact, it will be found almost necessary to change from one set to the other every 25 to 50 miles. Otherwise the engine will begin to miss and finally will stop. This is because the current flows through the cells so rapidly too much gas forms for the depolarizer to take care of and the cells polarize. After resting a while the cells will be restored or will recuperate, at least in part, to their former condition and can be switched on again.

But if there are eight cells connected in two sets of four in series and these two sets connected in parallel arrangement explained, the quantity or amperage of current required from each cell is lessened and they last very much longer—see foot note bottom of page 211, also index.

†Meaning of Resistance.

Electricity will flow more easily through some conductors than through others because there is a difference in their **resistance** to the flow of current.

Everything presents more or less resistance to the flow of current, and the **less resistance that** a substance presents, the better conductor it is. The **greater the resistance**, the less total current can pass; the pressure or voltage will drop‡ and the volume (amperage) will be reduced. In forcing a current through such resistance, **heat is produced, and the greater the resistance the greater will be the heat** (see ohms page 207, also index).

Positive and Negative Terminals.

Generator terminals: Every generator of electricity has two terminals; a positive (+) and a negative(—), that being the names given to the points from, one of which the current leaves (positive) and to the other of which it returns (negative).*

---

*The current always flows in the same direction, from the positive pole to the negative pole; it leaves the generator by the positive pole and returns by the negative.

Connections can be grounded either from the negative or positive pole—it makes no material difference. Manufacturers as a rule ground the positive terminal of a storage battery to the frame.

†**Resistance** is that property of an electrical conductor by which it opposes the flow of an electrical current, for instance, carbon, iron wire, German silver and water will permit current to flow through, but it opposes or offers resistance to the flow—see ohm, page 207. **A rheostat** is a device for the purpose of varying the resistance of an electrical current, see pages 474 and 460. ‡Termed a potential difference or energy lost. For instance, "two volts lost on a line," means this much pressure is lost in sending the current through the line.

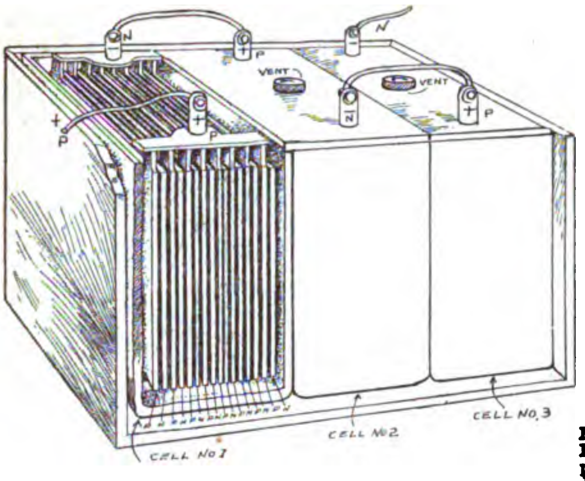


Fig. 2—The Ignition Storage Battery; a Chemical Generator of "Direct" Flow of Electric Current. Contained in a battery box. Sometimes called an accumulator.

The Storage Battery will also supply electricity to operate a Jump Spark or High Tension System of Ignition or a Low Tension "Make and Break" system. The Storage Battery for ignition consists of three cells placed in an acid-proof box. (See instruction on storage batteries.)

These cells are covered over with a nard rubber or coal tar composition, leaving the lead lugs projecting. These lugs connect one cell to the other and two ends are left "open," one a "Positive" or North, and the other a "Negative" or South. They are called "Positive" or "Negative" Terminals. Wires are connected to these terminals and the current is conducted over the wires to the ignition system.

When the Storage Battery is "run down" it is "recharged" by attaching wires from electric wires to the battery. (Will be explained later.)

The cells contain lead plates (N) negative and (P) positive, and are immersed in an acid solution.

Each cell gives two volts and are usually placed in a box and connected together, making a total of six volts this being the usual pressure required to operate a coil,

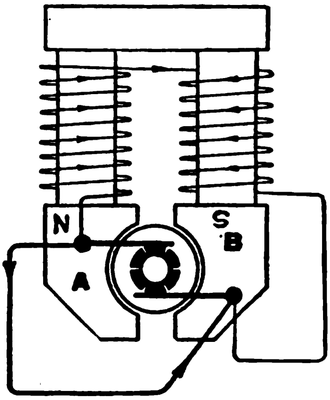


Fig. 3—The Dynamo; a Low Tension, Mechanically Generated, Direct Flow of Electric Current. The Dynamo will supply electricity to operate the coil of a Jump Spark or High Tension System of ignition or a low tens:on "Make and Break" System (not in use on automobiles to any great extent).

The Dynamo is more adapted for generating current to recharge the storage battery; the storage battery then supplies light and ignition.

Small "direct" current generators are also used on stationary and marine engines for ignition, where "make and break" or "wipe" spark ignition system is used.

The Dynamo has an "Electro-Magnetic" Field, meaning that the "pole pieces" are magnetized electrically.

The Magneto has "Permanently" magnetized "pole pieces" (will be described later).

The Dynamo generates a "Direct" or continuous flow of electricity, meaning the current flows continuously, whereas the current in a magneto is reversed and flows "alternately" and is not a direct flow.

The magneto is used in a different manner and is a separate and distinct system of ignition and will be described later.

The Dry Cell Battery (a Primary Cell); a Chemical Generator of a Direct Flow of Electric Current will also supply electricity for ignition, but is not reliable. Continuous use of dry cells will exhaust them or run them down rapidly and the pressure drops accordingly and thereby causes a "weak" spark. This battery will recuperate, however, if left standing for a while unused.

The dry cell battery is better adapted for ringing door bells or telephone work where the work required is not continuous.

The dry cell contains no liquid, but merely moisture, hence its name—Dry Cell Battery.

A is the filling or electrolyte, usually consisting of chloride of zinc, sal ammoniac, sulphate of lime and powdered charcoal (don't confuse this electrolyte with that used on a storage battery).

Six cells connected in a series connection is usually the combination for a set for ignition.

The positive pole of the dry cell is the carbon. The zinc being the negative.

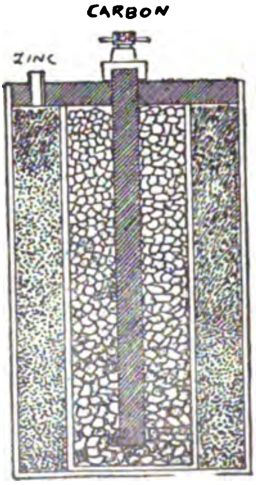


Fig. 4. Sectional View of a Dry Cell.

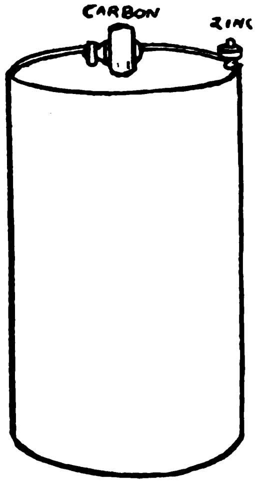


Fig. 4A. Complete View of a Dry Cell.

CHART NO. 101—Chemical and Mechanical Generators of a "Direct" Flow of Electricity. No reference is made here to Magnetos; this will be treated later, under a separate heading.

How Electricity is Made to Do Work.

Flow of current: The current only flows when the two terminals, or poles, are connected by a conductor.

A current will flow if any opportunity is presented; if there is no regular conductor, moisture will often make the connection. Because of this desire to flow, the current may be made to perform work.

If the circuit includes a coil or lamp, the current in flowing through the circuit from the positive pole to the negative pole is made to light the lamp or pass current through the coil.

The circuit, with the lamp or coil, presents a resistance to the flow of the current, and **if there is a short circuit that presents less resistance**, the current will return by it instead of going through the coil or lamp. Therefore, the circuit must be so arranged that the current cannot return to the generator without doing the work set for it.

A switch is provided to close this circuit when work is desired and to open the circuit when work is not desired. Therefore, **for ignition**, instead of a switch a **timer or commutator** is made to open and close the circuit at the time the spark is required.

Parts Necessary to Produce the Ignition Spark.

While there are several methods of producing the spark in the cylinder at the proper instant, they consist in general of the same parts.

In the first place, there must be a **generator** to supply the current of electricity; **spark plugs** or sparkers, also called igniters, in the cylinder, at which the spark is produced; a **timer** or cam arrangement, by which the exact instant of the spark may be controlled, and the **circuit**, consisting of the necessary wires or conductors.

Whatever the system may be, the current is produced by some kind of generator, and therefore a description of generators will be given before describing the systems.

Methods of Generating "Direct" Electric Current.

A current of electricity may be generated by **chemical** means, by cells; or **mechanically**, by a magneto or dynamo. (The magneto will be described further on as it generates an "alternating" current and the dynamo "direct" current.)

Chemical Generators.

Cells are of two kinds, "primary" and "secondary;" primary cells actually **making** the current, and secondary cells **storing** the current and giving it out as needed.

A dry cell or storage battery cell produces a "direct" flow of current and would be termed a "chemical" source of electricity.

The primary cells used for automobile work are called "**dry cells**," and consist of zinc cups, in which are placed sticks of carbon (see chart 101).

The cups are lined with some substance like blotting paper, and the space between the carbon stick and the cup is packed with bits of carbon and the necessary chemicals. The blotting paper and carbon bits are moistened with the proper solution, and the top of the cup sealed with tar, so that it is watertight. The zinc cup and the carbon stick each have a thumb nut at the top, called a "binding post," to which the wires are attached.

When the circuit is closed, the current of electricity flows from the carbon binding post over the circuit and back to the cell by the zinc binding post, the "carbon" being the "positive pole," and the "zinc" the "negative pole," in this type of cell.

Dry cells have a pressure or voltage, of about 1½ or 1¼ volts, and the volume of the current they produce, called the "amperage," depends on the size of the cell. The ordinary dry cell used in automobile work gives a current of 20 to 30 amperes.

When in use, a primary cell becomes exhausted, and the voltage drops gradually. When it has reached a point where it does not give sufficient current, it must be discarded, and replaced with a new one.

It should be remembered that dry cells are intended for "intermittent" *service, as for ignition starting where a magneto is used, but for continuous service, the dry cell is not a suitable source of current. After the engine has started dry cells for ignition are not very satisfactory fer they become exhausted in a short time.

For continuous current service the most efficient means of obtaining current is by means of a storage battery consisting of a battery of "secondary cells," or as it is sometimes called an "accumulator." This chemical type of electric generator is in more common use for ignition than the dry cells in connection with a dynamo—which will be explained further on.

****Secondary cells, also called "storage cells,"** or "accumulators," are usually charged with current from a lighting circuit, and may be recharged again when exhausted.

---

*The less continuously current is used from a dry cell the longer it will last or the more efficient it will be.

**Storage batteries will be treated under a separate instruction.

A storage battery consists of two or more storage cells. Each cell gives about 2 volts, therefore, a storage battery with three cells would give 6 volts, and is termed a "chemical generator." (This term is, however, not correct as it does not "generate" electricity but merely gives out only that which was put in it.)

A storage cell is made of prepared lead plates, placed in jars made of hard rubber or celluloid and filled with a solution of sulphuric acid and water, called the "electrolyte." The jar is filled with electrolyte until the plates are covered, a cover preventing it from spilling. A hole in the cover, closed with a plug, is used for examining the condition of the cell, and refilling it when necessary. Through evaporation, leakage or spilling, the level of the electrolyte may get below the top of the plates, in which case the jar should be refilled, enough electrolyte being added to bring it to the correct level.

Electrolyte is made by adding one part of chemically pure sulphuric acid to—from three to nine parts of pure water—preferably distilled water.

An instrument called a **hydrometer** is used to determine the correct solution, and when floated in the solution its scale should read about 1290 sp. gr.

†The terminals of a storage cell are usually marked with signs to indicate the poles; a "plus sign," the same that is used in arithmetic, being the "positive pole," and a "minus sign" being the "negative pole."

The poles are often painted, as well, red being the positive and black the negative.

A storage cell has a voltage of a little over 2 volts, and this will drop slowly to 1.8 volts, when it requires recharging. In this it is like water running out of a tank, when the tank is empty it is necessary to refill it.

Cell Connections.

On pages 207-9 the "principle" of cell connections was explained in order to exemplify the meaning of volts and amperes. Cell connections will now be explained. Bear in mind the same principles apply to storage battery cells.

One cell in a storage battery or dry battery will not give enough current to produce the spark required to ignite the mixture, and therefore, three, four or more are used, connected together.

The most usual form of connection is in **series**; the negative pole of one cell is connected to the positive pole of the next, so that the current from one cell must pass through all of the others in order to return to where it started. (See chart 102, fig. 1.)

This method of connecting increases the voltage as many times as there are cells; for instance, if there are four cells of 1½ volts each, the voltage of the battery of cells will be six volts. The volume or amperage does not change, being the same that it is for one cell. (See fig. 2, page 207.)

Another method of connecting is in **parallel**; all of the positive poles are connected to one wire, and all of the negative to another. (See chart 102, fig. 2.) This gives the same voltage (pressure) as one cell, but increases the amperage (quantity) as many times as there are cells.

A third method is to connect the cells in **multiple series.** (See chart 102, fig. 3.) In this the cells are divided into two equal groups, each group being connected in series, and the two groups being connected with the circuit in parallel with each other. This gives a voltage of one-half what it would be if all were connected in series, and an amperage of one cell multiplied by the number of groups.

Mechanical Generators.

A mechanical generator, which is driven by the engine, produces a current of electricity, and its action depends on "magnetism," which is the property sometimes possessed by iron or steel, by which they attract other pieces of iron or steel.

A generator consists of two parts; the "poles," between which the magnetic field flows and the "armature," which revolves in this magnetic field, and produces the current of electricity. (See fig. 4, chart 102.)

The field is made in two ways; it is either a "permanent magnet," that is, steel that is magnetized so that its magnetism does not change, or an "electro-magnet;" that is, a coil of wire wound around a soft piece of iron, which is a strong magnet only while electricity is flowing through the coil.

*When the field is a permanent magnet (fig. 5, chart 102), the generator is called a "magneto;" when the field is an electro-magnet (fig. 4), the generator is called a "dynamo." (See chart 101 and 102.)

The armature has a core, consisting of soft iron, with insulated wire wound around it endways. There are two types; a "drum" type and a "shuttle" type. The drum type could be revolved in either the "electro" or "permanent" magnetic field and would generate "direct" current. The "shuttle" type is used only on generators in which the magnetic field is produced by permanent magnets and always generates "alternating" current. (Will be explained under magnetos further on.)

The voltage of a magneto or dynamo depends on the size and quantity of wire wound on the armature and field coils, and on the speed.

Terminals: Mechanical generators usually have but one terminal, the other being "grounded," which will be explained. Where there are two terminals and "direct" current generators, they are marked as the terminals on a storage cell are marked. (+positive,—negative.)

---

†When the poles of a storage battery are not marked the polarity can be determined by their natural color; the positive is darker, usually a brown color, whereas the negative is gray. *If armature is of the "shuttle" type.

When using "chemical" generators, such as a storage battery; the circuit is also (quite often) grounded on one side.

*Grounding the Circuit.

When the current of electricity is required to do work, as, for instance the producing of a spark in the cylinder, using a "make and break" ignition system for example, it must be taken to the igniter through a coil, by means of a wire but may be returned to the generator by means of a ground." Which is usually abbreviated as "G" or GRND and designated by a sign as shown in chart 109. See chart No. 102, fig. 7; and fig. 3, chart 103; dotted lines show path of current through metal of engine.

The frame and engine of an automobile are made of metal, and therefore will conduct electricity.

If the negative pole of the direct current generator is attached to the metal frame or engine, and a wire attached to the positive pole, the current will flow in the circuit when the positive wire is touched to any other metal part of the frame or engine, for the metal acts as a conductor and permits the current to return to the generator.

This method saves wire, for wire is used only to take the current to where it is needed, the metal of the frame or engine bringing it back again.

**Switches.

When the current for the ignition is supplied by battery, it is usual to have two sets (fig. 1, chart 103), and is used to start the engine; after engine is started, the dynamo or magneto supplies the current. The reason for this is due to the fact that a battery supplies a **constant** source of electric supply, whereas a mechanical generator generates current only when running.

A switch is placed in the circuit, so that either may be used. They are made in many forms, but a simple form is a flat piece of spring brass, pivoted at one end, so that it may swing from side to side. The free end may touch either of two knobs of brass, one on each side, or be between them without touching them. Each of the knobs are connected to one of the sets of batteries, or one to the battery and the other to the dynamo, and the flat piece of brass is connected to the ignition circuit.

Thus when the free end of the switch is swung to one side, or the other, it rests on one of the knobs, and the corresponding battery is thrown in circuit, furnishing the current for the ignition.

When the switch is between the knobs, it is out or "off" of contact, and the circuit is broken. Thus a switch serves not only to connect either of the two sources of current, but also to break the circuit, which, of course, stops the engine.

The switch lever can be detached from some makes of switches; when it is withdrawn, it breaks the circuit regardless of which side the switch is on. Thus only the holder of the lever may run the car.

Ignition Systems.

There are two systems of ignition used for automobile engines; "**low tension system**" and the "**high tension system**;" the source of electric supply being either by chemical means as: dry cells, or a storage battery, or mechanical means as: a magneto or dynamo (also called generator). (The magneto is explained further on.)

The word "tension" means pressure or voltage; high tension being high voltage, and low tension low voltage.

The low tension system of ignition is used on only a few makes of automobiles. The low tension system was formerly used to a great extent on boat engines and is still used to a great extent on stationary engines.

The low tension system uses a low tension single wound primary coil as per fig. 7, chart 102 and its source of electric supply can be a dry or storage battery, or dynamo. Low tension magnetos are also used, but the coil is wound on the armature (treated under "Low Tension Magnetos.")

The high tension system of ignition is the approved system now in use on very near all makes of cars. The high tension system may be either by a high tension coil and a battery; high tension coil and low tension magneto; high tension coil and dynamo in connection with a battery—or by a high tension "magneto" alone.

In this Instruction and in number seventeen, we deal only with coil ignition. Both low tension and high tension. Magnetos will be treated further on.

---

*Either the positive or negative side can be grounded as it makes no difference. Manufacturers as a matter of standardizing, are grounding the positive pole of storage battery (+).

**See page 275—"magneto switch"—note switch is closed to stop ignition.

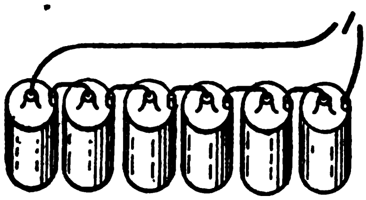


Fig. 1—Series. Zincs connected to carbon.

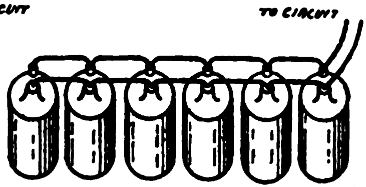


Fig. 2—Parallel. Zincs connected together. Carbon connected together.

CELL CONNECTION

Fig. 1 is the usual method. This method gives the voltage of six cells and an amperage of one cell.

Fig. 2. This method gives the voltage of but one cell and an amperage of six cells.

Fig. 3 is a method used for emergency. In this case the reader will suppose that two sets of dry cells supply the current for ignition; one set is used for a while, then the other; if both sets run down, then connect them in multiple as shown. This method gives a voltage of five cells and an amperage of two cells.

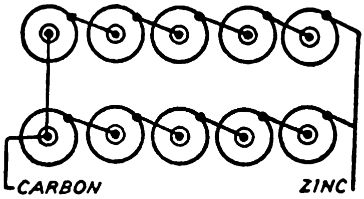
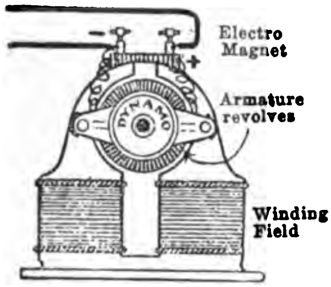


Fig. 3—Multiple Series. See text for explanation.



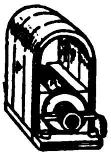


Fig. 4—A dynamo, a mechanical generator of "direct" current. Note the electro winding on field magnet. The armature is "drum" type.

Fig. 5—A magneto with "permanent" magnet. If armature is "shuttle" type (see magnetos) the current will be "alternating," if "drum" type, direct.

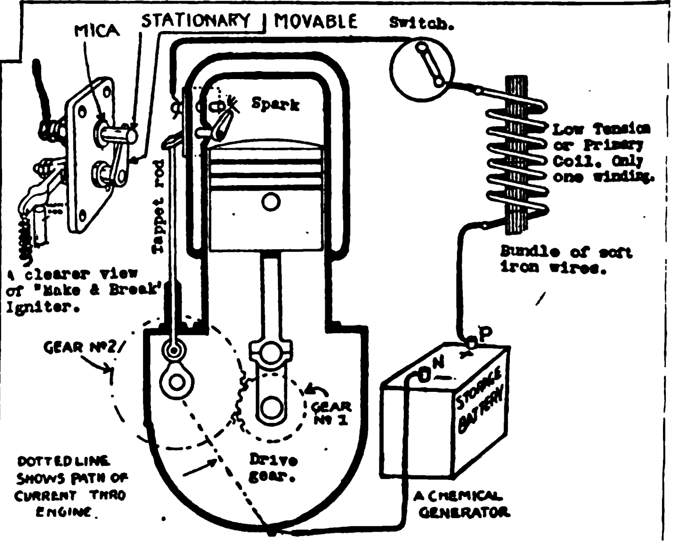

MICA
STATIONARY
MOVABLE
Switch.
Spark
Tappet rod
Low Tension or Primary Coil. Only one winding.
Bundle of soft iron wires.
A clearer view of "Make & Break" Igniter.
GEAR No 2
GEAR No 1
Drive gear.
DOTTED LINE SHOWS PATH OF CURRENT THRO ENGINE.
P
N
STORAGE BATTERY
A CHEMICAL GENERATOR

Fig. 7—A make and break low tension system of ignition.

The igniter is shown, which makes and breaks the low tension current as it flows from the positive pole of the battery to the single-wound low tension coil through switch, then to the mica insulated electrode.

*When the nose of the cam strikes the tappet rod, this rod makes and breaks the flow of current and creates a flash or spark (as by hand, fig. 6). The current flows from positive pole of battery to stationary electrode on engine, thence through moveable electrode to metal of engine—thence by way of grounded circuit to battery.

In the above illustration, the coil through which the current passes is a low tension coil, and the system of ignition is the "make and break" system. Either the dry cells, storage battery or the dynamo will supply the electricity. Either of these same sources of electricity would supply electricity for the jump spark or high tension coil also. This latter system will be treated further on. The magneto would require special connections, if used, and will also be explained further on.

The spark should occur just as piston is on top of its stroke or slightly before.

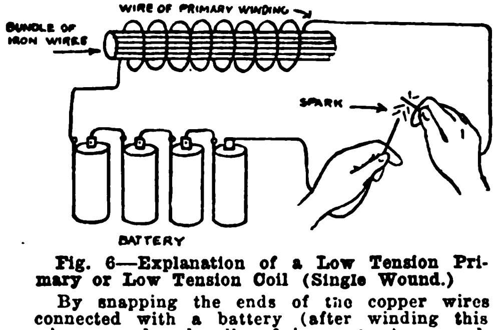


Fig. 6—Explanation of a Low Tension Primary or Low Tension Coil (Single Wound.)

By snapping the ends of the copper wires connected with a battery (after winding this wire around a bundle of iron wires) a spark will be produced. The wires must be "snapped" or separated suddenly, and the current must pass through the single-wound or primary coil.

CHART NO. 102—Cell Connections. Mechanical Generators. Make and Break Principle of Ignition.

*Note the points do not remain together when not operating—they are slightly apart. The cam or tappet arrangement causes the spark to "make" and suddenly "break," hence the term "make and break."

Low Tension Coil System of Ignition.

If the ends of the wires of a primary or low tension coil, are connected with a battery or mechanical generator and connected together, the current will flow, and if then the ends are **separated suddenly** a spark will be formed between them. The more powerful the current, the larger will be the spark. (See fig. 6, chart 102, this illustration explains the fundamental principle of coil ignition, therefore study it carefully.)

The movable electrode is operated by a cam arrangement, exactly as the exhaust valve of the engine is operated. As the spark is needed only once during two revolutions of the crank shaft, the cam is attached to the half-time shaft, and operates the electrode by a rod called a tappet.

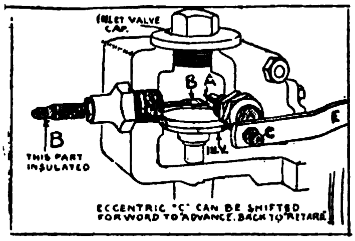
The "stationary electrode" is insulated from the cylinder with mica, and one wire of the circuit is connected to it. The "movable electrode" is operated by a cam, which is in contact with the current from the grounded wire of the battery and which allows the current to pass from it to the metal of the cylinder.

When the two points are in contact, the current flows from the positive pole of the battery by a wire to the stationary electrode, then to the movable, because the two are in contact, and back to the battery by the ground.

When the two electrodes are separated by the cam acting on the movable one, the circuit is broken, and a spark formed between them.

Chart No. 103, fig. 1, shows this ignition system; it shows two sets of batteries connected to the switch in such a manner that either set may be used.

While any battery would give a spark, a strong one is needed to ignite the charge suddenly and completely, and to do this it is necessary to use a strong current. Therefore several cells are connected together, usually 5 or 6. One set is used a while then the other. Dynamos, storage batteries and low tension magnetos are also used.


INLET VALVE CAP.
B
A
E
C
B
THIS PART INSULATED
IN.V.
ECCENTRIC "C" CAN BE SHIFTED FORWORD TO ADVANCE, BACK TO RETARD

Wipe spark ignition is similar to the "Make and Break" in every respect, except that makes a **wiping** and **rotary** motion as the electrode (A) of the igniter revolves; being operated by an eccentric rod (E) from the cam gear.

The other electrode (B) is stationary and looks very much like a spark plug. This type of ignition is never used on the automobile; but is here shown so that the reader can master the elementary principles of the different ignition systems.

The Low Tension Coil.

We have learned the different sources from which electricity can be obtained for ignition. Also the first principle of ignition, which is the old style "make and break" igniter using a low tension or primary coil. This system is seldom used, only on stationary engines, however, **it will be well for the reader to master the principle of the low tension coil, as it is the foundation for building up a high tension coil or magneto armature winding.** (See fig. 6.)

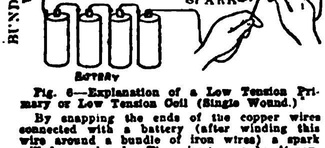


Fig. 6—Explanation of a Low Tension Primary or Low Tension Coil (Single Wound.)

By snapping the ends of the copper wires connected with a battery (after winding this wire around a bundle of iron wires) a spark will be produced. The wires must be "snapped" or separated suddenly, and the current must pass through the single-wound or primary coil.

The current is strengthened, or **intensified**, by the use of a simple coil, called a **primary or low tension coil.**

Construction: Consists of a bundle of soft iron wires, called the "core," around which is wound several layers of well-insulated copper wire. (See also coils in chart 103.)

A current of electricity passing through the wire will make the core a magnet, the magnetism ceasing as soon as the current stops flowing. The magnetism of the core acts on the current of electricity, and intensifies it, and making it strong enough to produce a good spark between the electrodes.

The reason for the current being intensified requires an understanding of electrical engineering to make it clear; it is sufficient for the automobilist to understand that the current **is** intensified.

The positive wire of the battery leads to one terminal of the wire wound around the core of the coil, and the other terminal of the coil winding is connected to the stationary electrode.

Because the action of the cam moves the movable electrode, it can be seen that making the cam operate sooner or later will make the spark occur sooner or later. The cam is therefore arranged so that it may act sooner or later on the tappet and electrode, and is controlled by a lever, so that it can be advanced or retarded just as a timer on a high tension coil system.†

---

††**The low tension "make and break" ignition** system: two metal points (electrodes, fig. 7, chart 102) are set in the combustion space of the cylinder, one of them being stationary, and the other movable, so that it may touch the other or be separated from it.

The two points are called "electrodes," and form what is termed, the **igniter**. The two points are connected in the ignition circuit, so that when they touch the current passes from one to the other, and when they are separated a spark is formed between them.

†The make and break system is seldom used on automobiles. Used more on stationary engines. The **"wipe spark" is similar; also used on stationary** engines, see above, and "Dyke's Motor Manual."

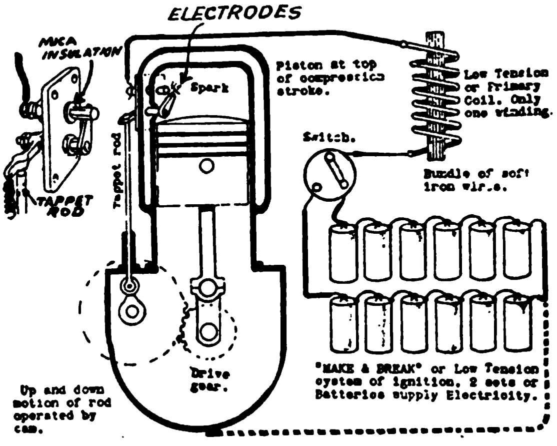

ELECTRODES
MICA INSULATION
TAPPET ROD
Tappet rod
Spark
Piston at top of compression stroke.
Low Tension or Primary Coil. Only one winding.
Switch.
Bundle of soft iron wires.
Drive gear.
Up and down motion of rod operated by cam.
"MAKE & BREAK" or Low Tension system of ignition. 2 sets of Batteries supply Electricity.

FIG. 1 MAKE AND BREAK SYSTEM OF IGNITION. WITH DRY CELLS, 2 SETS.

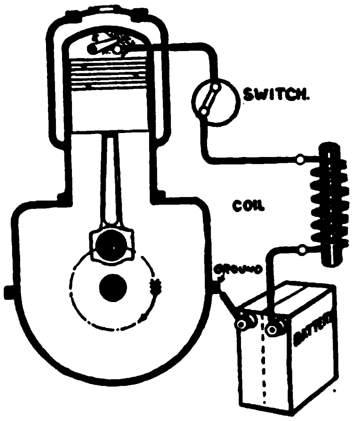


FIG. 2 MAKE AND BREAK, IGNITION WITH STORAGE BATTERY

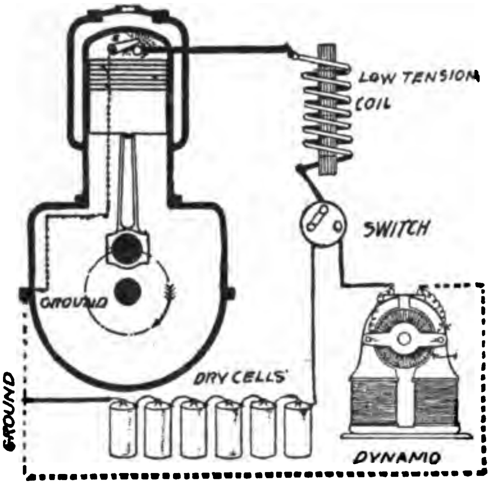


FIG. 3. MAKE AND BREAK. WITH DRY CELLS TO START ON, AND DYNAMO TO RUN ON.

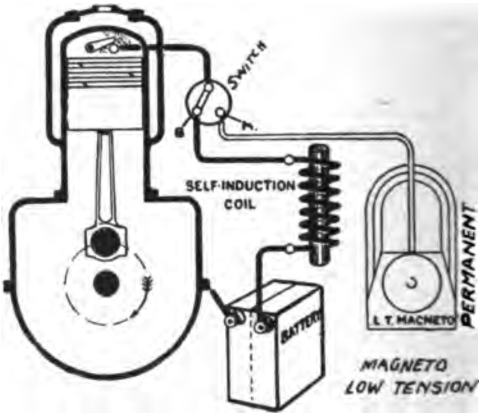


FIG. 4. MAKE AND BREAK, WITH BATTERY TO START, AND MAGNETO TO RUN ON.

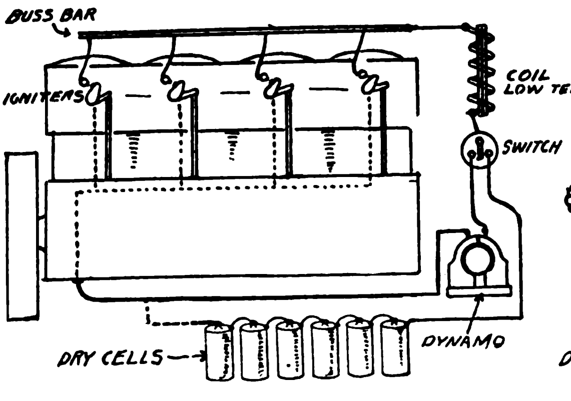


FIG. 5 4 CYLINDER MAKE AND BREAK WITH DRY CELLS TO START ON, DYNAMO TO RUN ON.

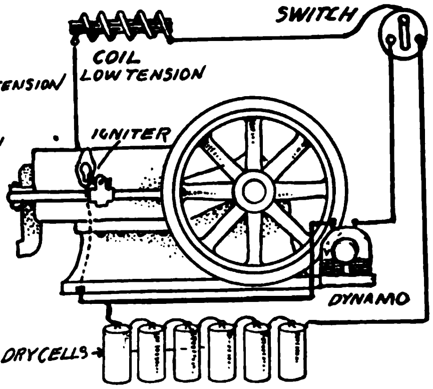


FIG. 6. STATIONARY ENGINE WITH DRY CELLS TO START ON, DYNAMO TO RUN ON.

CHART NO. 103—Diagrams of Wiring for the Low Tension "Make and Break" System of Ignition using Dry Cells or Storage Batteries (chemical source), and Dynamo or Magneto (mechanical source).

Wiring Diagrams of the Low Tension "Make and Break" Ignition System.

A "make and break" system (see chart 103); requires less care in wiring than the high tension or jump spark system, but is not suitable for high speed automobile engines.

The first difficulties were; insulating the stationary spark point, and making an easy working but tight joint for the moving spark point, although this has been largely overcome, the jump spark or high tension, has proven a superior ignition and it is to this latter system we will confine our attention in the following instructions. It is well, however, for the reader to master the low tension system of ignition in order to understand the high tension system.

Wiring for two sets of dry cell batteries: In fig. 1, chart 103, we have two sets of dry cells as the source of electricity for the make and break system of ignition. One set is used a while and then the other. **Dry cells run down rapidly**, therefore this system is seldom used.

Wiring for batteries to start on and the dynamo to run on: The dynamo, which generates a direct flow of electric current, is usually placed so that it is operated by the engine, and the usual plan is to start the engine with dry cells, and after engine is started, the dry cells, are switched off and the dynamo supplies the electric current. (See fig. 3.) This system is used quite extensively on stationary gasoline engines, as well as a great number of marine engines.

The storage battery for make and break ignition: This system (see fig. 2), is practical if the storage battery can be recharged. The storage battery will supply a certain quantity of current for a certain period of time; for instance, suppose the storage battery was a 60 ampere hour battery, and the ignition system used one ampere of current per hour; in this way we would have a sufficient quantity of electricity from the storage battery to run the ignition for 60 actual hours.

Suppose the engine only runs three hours per day—we would use three amperes of the 60 in one day; therefore we would have 57 amperes left, which would run 19 more days of three hours per day.

The storage battery delivers the same pressure until all the amperage or quantity is gone, whereas a dry cell, not only loses in amperes or quantity, but it loses its pressure in a very short time of service.

The usual pressure required to force the current through the coil is six volts (pressure). The storage battery will hold this pressure until the quantity of current is all gone. The dry cell drops in voltage rapidly, and therefore weakens the spark. When a storage battery runs out, it is restored with electricity. When a dry cell runs out of current, it is thrown away.

Sometimes we see a storage battery and a dynamo or magneto connected so that the engine is started from the storage battery and then switched to the dynamo, after the engine is running. When a dynamo or magneto is used for supplying electricity, it is usual to have either a set of dry cells, or a storage battery to start with. The reason for this is; a dynamo or magneto must first run in order to generate electric current, and the usual plan of cranking an engine will not speed up the dynamo or magneto fast enough so that it will generate current. Therefore, the dry cell and storage battery are used for starting, and after the engine is started and is running fast enough for the dynamo to generate current, the switch is thrown from the battery to the dynamo.

A low tension magneto for ignition: The subject of magnetos (low and high tension) is treated under a separate instruction.

The low tension magneto is used quite extensively for make and break systems of ignition, in connection with a set of dry cells to start with, on the same principle as the dynamo combination. The magneto, however, differs from the dynamo, in that it supplies an "alternating" current instead of a "direct" current.

No coil is necessary in connection with the low tension magneto, but the coil in the diagram (fig. 4) is used in connection with the battery for starting. The coil used with the magneto is wound on the armature of the magneto. This subject will be treated further on.

A four-cylinder make and break system of ignition with dry cells and dynamo. All of the diagrams shown are illustrated on one-cylinder engines. In fig. 5, chart 103, a four-cylinder engine, with make and break system of ignition, is connected up, using a combination of dry cells to start with, and a dynamo to run on.

Note—**The above systems are not now used on automobiles**, but were formerly used in the early days of motoring. **The reason for explaining the old systems** of ignition, is due to the fact that the underlying principles of the more modern systems are founded upon the principles of these early days. Therefore it is essential that they be mastered first in order to more clearly understand the modern systems treated farther on.

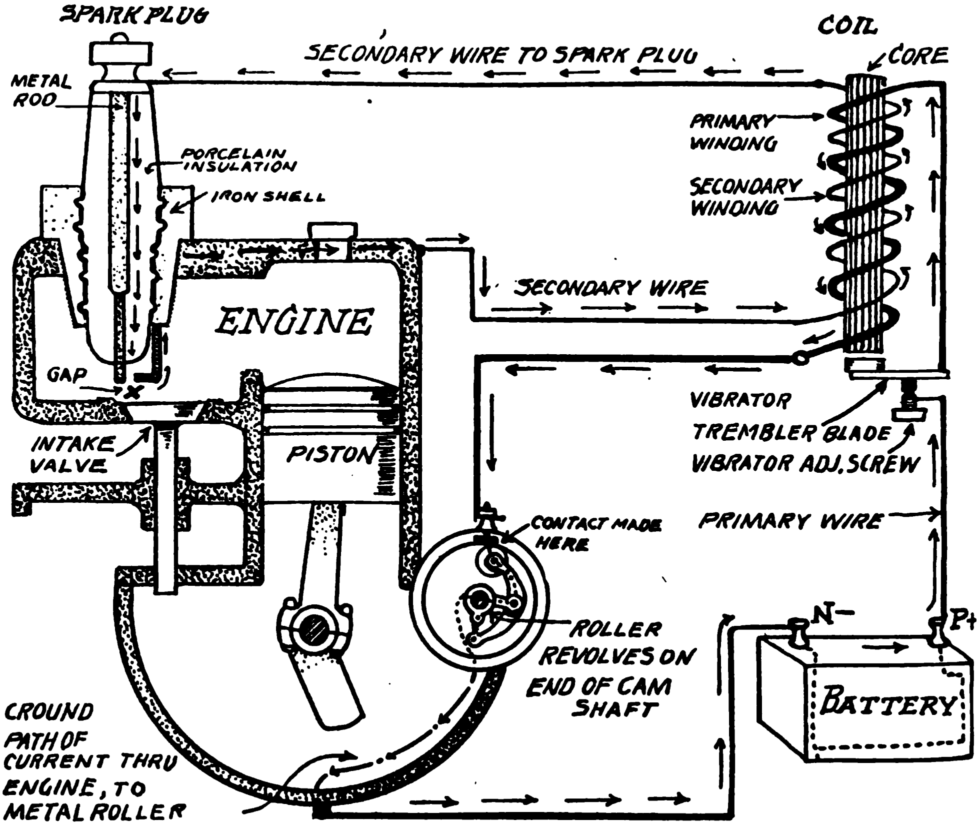


Fig. 1.—An exaggerated drawing, made for the purpose of illustrating how the spark plug is screwed into the combustion chamber of the engine, and how the current is carried from the battery through the primary winding of the coil, to commutator, etc. Trace the circuit with your pencil.

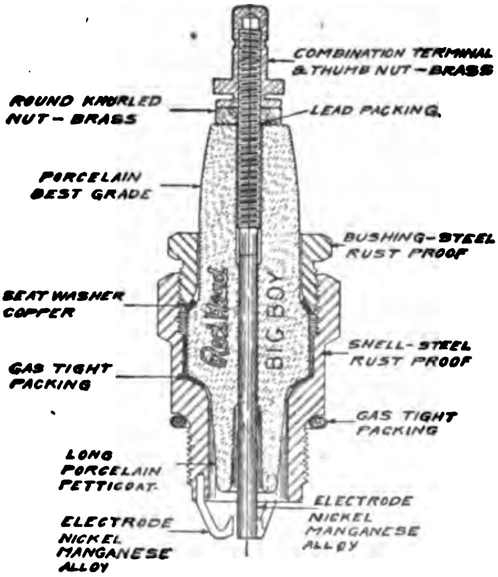


Fig. 2.—Names of Parts of Insulated Spark Plug, Especially Made for Magneto Use. Note the heavy terminals. Magnetos give a heavy "fat" spark, but points are set very close. (1/64-inch.)

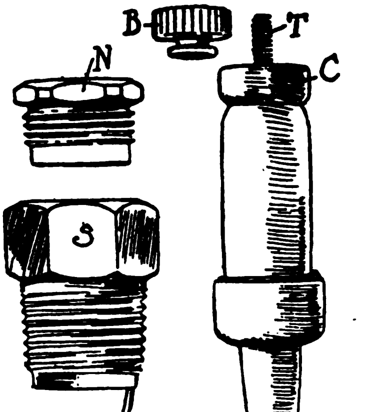


Fig. 3.—Parts of a Porcelain Insulated (C), Spark Plug Separated. A Type of Plug Usually used with a Jump Spark Coil System of Ignition.

S—Is the iron shell which screws into the engine cylinder.

N—Is the brass bushing which holds the porcelain (C) in the iron shell.

C—Is the porcelain with rod (T) running through it.

B—Is the lock nut or thumb nut which holds the secondary wire. (B) screws on the end of (T) to hold wire in place.

The above spark plugs are known as the "Red-Head" brand.

CHART NO. 104—Explaining the flow of the Primary and the Secondary Currents in the Hig Tension Coil System of Ignition, and parts required for a High Tension Coil System of Ignition. See page 225 for description of commutator.

Spark plug is usually placed over the inlet valve. See note bottom of page 219, also index for "Spark
See also pages 233, 235 and 238.

INSTRUCTION No. 17.

IGNITION; HIGN TENSION COIL: Wiring of High Tension Vibrator Coil Systsm. Purpose of the Spark Plug. The Induction Coil Principle. Magnetism. Mechanical and Electrical Vibrators. Commutators. Commutators and Distributor. Timers. Master Vibrator. The Coil Condenser.

The low tension, or make and break, system of ignition, described in the last lesson is not used very much. The "high tension," or as it is sometimes called the "jump spark" system, is the system in general use.

Purpose of Spark Plugs.

You are more or less familiar with the ordinary spark plug that is used in connection with ignition systems to give a spark inside the cylinders of the engine. In chart 104, are two views of two typical spark plugs, one showing plug as if cut in two, called a sectional view, the other view shows plug disassembled. The metal part of plug (T) acts as a conductor of the current, while the porcelain (C) represents the insulating material, which is composed of porcelain or mica. (see pages 233 to 239.)

*A spark plug is screwed into each cylinder of the engine, and when the piston is in the right position to receive a spark, a current of electricity is sent along the metal center part (called the firing pin) of the spark plug and across the small air gap at the bottom and into the outer sleeve. Although this air gap is only about 1-64th to 1-32nd of an inch wide, the air in the gap offers such a tremendous resistance to the current that it requires in the neighborhood of 16,000 volts' pressure to force a very small quantity of current across the gap. In other words the current must be of such high pressure that it will **jump** across a space between two points, forming a spark as it passes. See "gap" fig. 1, chart 104. Also pages 542 and 699.

The current produced by a battery and low tension coil as used for the "make and break" system, would not have enough pressure to jump across this gap, therefore must be **intensified** (or pressure increased) still more.

Where simple low tension coils are used for the make and break system, as explained in chart 102, fig. 6; coils of another kind, called **high tension induction coils** are used to **intensify** the current sufficiently to force it to jump across the open space. Therefore it is called the "jump spark" or "high tension" (meaning high pressure).

**The Jump Spark or High Tension Coil.

Construction: An induction coil or jump spark coil, consists of a core of soft iron wire, over which is wound a few layers of insulated copper wire, which is called the **primary winding** (in other words, this is our original low tension coil, fig. 6, chart 102).

Over the primary winding is wound a great number of layers of exceedingly fine copper wire, insulated, called the **secondary winding.** (See fig. 1, chart 104.)

When a current of electricity flowing through the primary winding from some source of electric supply is suddenly stopped and then started again, another current of great pressure flows in the secondary winding—**although the two windings are not connected**—this is called "**induction,**" or temporarily "**induced**" current.

This "**induced**" current in the secondary winding is also called the "**secondary current,**" and flows in waves, there being a wave of current whenever the primary or battery current is stopped and started again by a contact breaker of some sort.

---

*The position of the spark plug in the cylinder can be placed as follows; over center of piston, over exhaust valve, or over inlet valve. The first position is not the best, as it is found that it too easily becomes fouled. If screwed above the exhaust it will likely miss fire; this is caused on account of the dead gases surrounding it. The correct position is over the inlet valves, as it will be kept cool by the inrush of fresh gas, and it is in an atmosphere perfectly suited for explosion, directly the spark appears, as it is the more perfectly scavenged part of cylinder, i. e., in the direct path of the fresh gas. The plug is usually placed over the inlet valve on "T" or "L" head cylinders. In the overhead valve type, the plug is placed in the top center or in the side of cylinder. They are exposed to the full heat of the explosion when over head directly in center of bore, consequently in a high compression engine of this type, a well made plug must be used.

Many of the overhead valve engines, have the plugs in the side of the combustion chamber. See index "Overhead Valves," "Compression," "Spark Plugs" for additional information.

**Also called "induction coil," "transformer coil," "secondary coil."

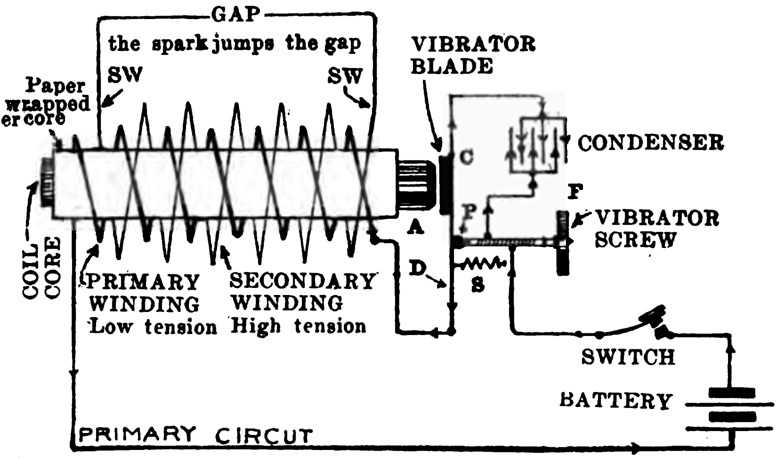


Fig. 1—Another view of a jump spark coil, also called an induction coil, high tension coil or secondary coil. The illustration explains how the primary and secondary winding is wrapped over the core and how the magnetic vibrator interrupts the flow of electricity from battery through the primary wire circuit, and how the spark jumps the "gap" of the spark plug. When switch (or timer) is closed, the current flows from battery through this primary wire wrapped around the core or bundle of iron wires (A), (trace with pencil). The bundle of iron wires become magnetized when the primary electric current flows around it. This magnetism causes the vibrator blade (C) to be drawn away from its connection with screw (F) at platinum points (P).

The moment this vibrator is drawn away from screw (F) the circuit is broken and the bundle of wires (A) loses its magnetism, therefore the vibrator (C) is again drawn back to screw (F) by spring (S), but the moment the contact is again made—(A) again becomes magnetized and draws the vibrator (C). This is repeated so fast the vibrator (C) simply buzzes. The greater the buzz, the greater the spark or voltage and more current consumed.

When this vibration takes place the current is "induced" in the secondary winding (wrapped over the primary winding) by "induction" and this induced current is intensified, that is, the pressure is raised to such a high voltage it will jump the gap as shown, or if one end of this secondary winding (SW) is connected to a spark plug and other end grounded, then it will jump the spark plug gap.

A timer is used instead of a switch but its purpose is the same, see page 222.

A condenser is connected or "shunted" around the points (P) for purpose explained on pages 228 and 229.

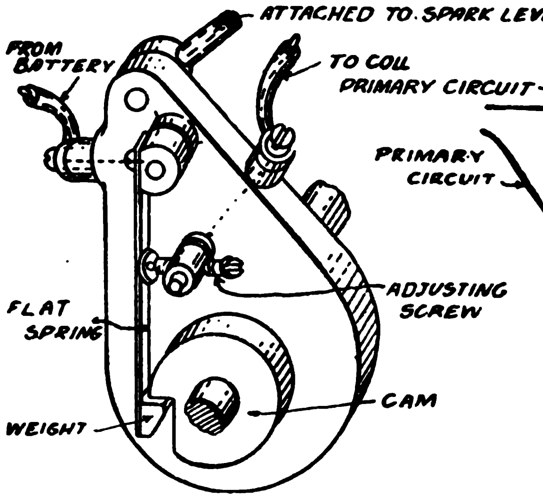


Fig. 2—A Mechanical Vibrator. (Seldom used.)

The purpose of this device is to open and close the primary electric circuit in rapid succession mechanically, instead of the magnetic vibrator.

When this type of vibrator is used the vibrator on coil is not necessary as shown in figs. 3 and 1.

The case is made of fibre or metal, but the spring and screw are insulated from each other.

The above timer is used principally on single cylinder motorcycle engines.

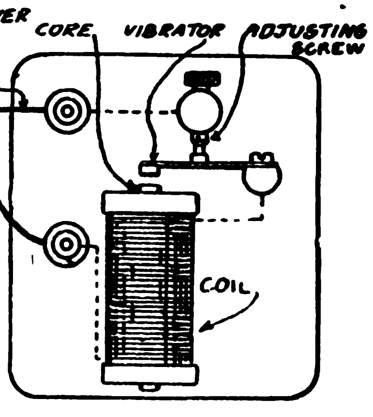


Fig. 3—A Magnetic Type of Vibrator. (Same as on coil in fig. 1.)

This illustration shows a vibrator placed on the coil, and operated electrically.

There must now be a "commutator" or timer to close and open the circuit at the proper time, in order to operate this vibrator electrically. If engine is a four cylinder engine, a commutator with four contacts, as shown on page 222 would be required.

CHART NO. 105—Diagram explaining the double wound High Tension Coil and action of the Vibrator. The Mechanical Vibrator and the Electrical Vibrator (vibrators are sometimes called "tremblers.")

Elementary Principle of a High Tension Coil.

The reason for this separate current flowing in the "secondary" winding can only be understood after studying electrical engineering; however, we will endeavor to give the reader the elementary principle of "magnetism," "lines of force" and "induced" current, also the relation of volts and amperes to cell connections, as follows:

In order to produce a spark in the cylinder of engine sufficiently strong to ignite the compressed gas, it is necessary to have the *current producing the spark under great pressure. The pressure or voltage of a storage battery or a number of dry cells is not enough, so it remains to make this pressure greater so that it may be used with good results.

Raising the voltage of the battery current is accomplished by means of an induction coil (high tension coil) called a spark coil. In order to fully understand the induction coil, a few elementary steps must be learned first.

An ordinary horseshoe magnet is known to attract iron and steel. The magnet will have a holding effect on the iron or steel even if the magnet is separated from the iron by a piece of paper or glass. The magnet attracts the iron because of some mysterious, unseen force that is called magnetism. We cannot see the magnetism, nor can we feel it, but we can see and feel the effects of it. If a number of iron filings are attracted by a magnet, it will be noticed that the filings arrange themselves in rows from one pole of the magnet, to the other.† It is supposed that the filings arrange themselves in lines because the magnetism goes from pole to pole, or end to end, in lines. We cannot see these lines, but their peculiar characteristics has resulted in their being called "lines of force."

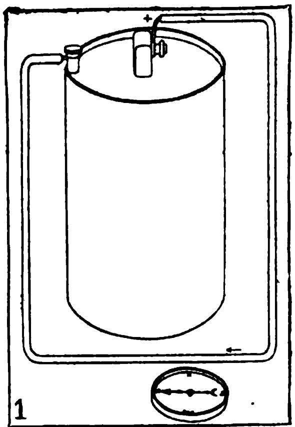
In other words, that unseen, mysterious force which we call magnetism is expressed in "**lines of force.**" All the lines of force between the two poles of the magnet comprise a "**magnetic field.**"

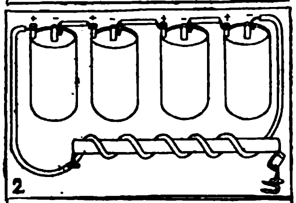
Now, the magnetism or "magnetic lines of force" manifest themselves not only around a magnet, but around any current carrying wire. This can very easily be proven. In fig. 1, a battery is being exhausted through a conductor. If a compass is held near the wire shown, the needle of the compass will suddenly take a turn and then remain still. The current passing through the wire causes magnetism to exist around the wire for a certain distance, and this magnetism, acting upon the steel needle of the compass, causes it to turn.

If this simple experiment is tried it will be found that the compass needle will turn **in the direction of the flow of "lines of force" around the conductor. The current in the wire flows from the carbon or positive side and in the direction shown by the arrow. It should be borne in mind, then, that around every conductor of electricity there are lines of "magnetic force" or, as we shall call it, a "magnetic field."

The magnetism from the magnet is called "natural magnetism." But magnetism may be produced in another way by the use of what is called an "electromagnet." The apparatus is shown in fig. 2. An iron bar has packed around it some paper or other insulating material. A coil of copper wire is slipped over the iron, which is called the core. The two ends of the coil or wire are attached to a number of dry cells, connected in series. If a piece of metal such as steel is placed near the end of the core it will be attracted by the core. If the wires from the battery are removed the pieces of iron or steel at the end of the core, are no longer attracted.

In other words, as soon as a current is passed through the copper coil, the iron core is magnetized, but as soon as the current stops flowing the magnetism stops. We do not know why the core becomes a magnet, except it be by the presence of a magnetic field around the copper coil. This magnetic field pierces any thing. This is here evident because the core is insulated by paper. It could just as well have been wood or glass or stone.





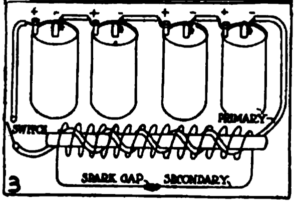


Fig. 1. Note there is magnetism even in a copper wire, if connected to a source of electric supply.

Fig. 2. A primary single winding of copper wire (usually of larger size than the second winding), around a soft bar of iron will cause bar to become magnetised.

Fig. 3. If another winding (smaller wire), is wrapped around the primary, a high tension current of electricity will be "induced" into the second winding.

It has just been shown that the current flowing through a coil of wire affects an iron bar within it so as to make the bar be-

---

*Note—"Current" means electricity or the flow of electricity.

**Through an error, compass needle in fig. 1, is shown parallel to current flow, instead of lines of force. Needle should point towards you. †See page 267.

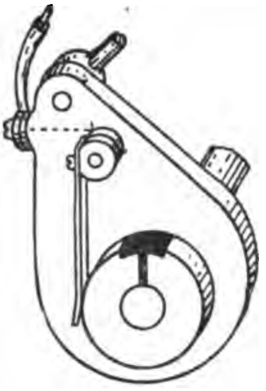


Fig. 1—Simple form of brush type of commutator.

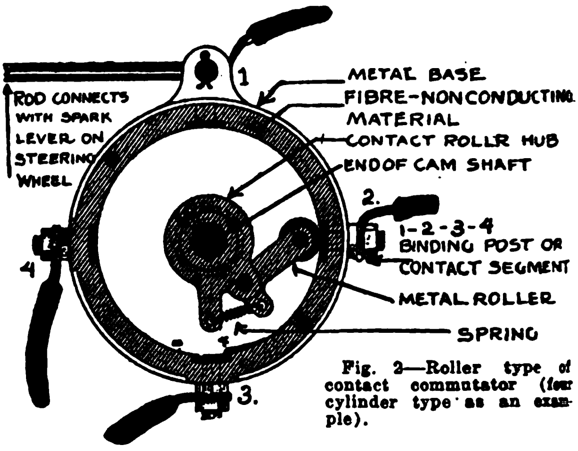

ROD CONNECTS WITH SPARK LEVER ON STEERING WHEEL
1
METAL BASE
FIBRE-NONCONDUCTING MATERIAL
CONTACT ROLLR HUB
ENDOF CAM SHAFT
2.
1-2-3-4 BINDING POST OR CONTACT SEGMENT
METAL ROLLER
SPRING
4
3.

Fig. 2—Roller type of contact commutator (four cylinder type as an example).

Fig. 1—The revolving part is fibre (insulation). The black part is a metal strip or segment grounded to cam shaft. The blade or brush is insulated from the base. This brush connects with primary winding of coil, thence to battery and one end of battery is grounded. When the segment touches the brush, the contact is completed and causes the vibrator to vibrate.

Fig. 2—The principle is the same as in Fig. 1, except a roller makes the contact with segments. Each segment is connected with the primary winding of coil. There are as many segments and coils as there are cylinders.

Fig. 3—This type of timer is used in connection with a coil without of vibrator. It makes a single hot spark as explained

There are as many cams as there are cylinders. On the above, there are four cams. Therefore, it is suitable for a four cylinder engine. The above timer is the Delco.

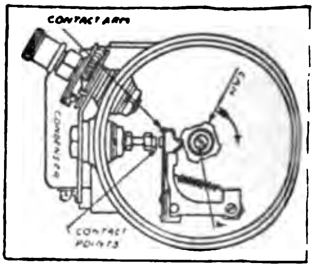


Fig. 3—The modern type of timer.

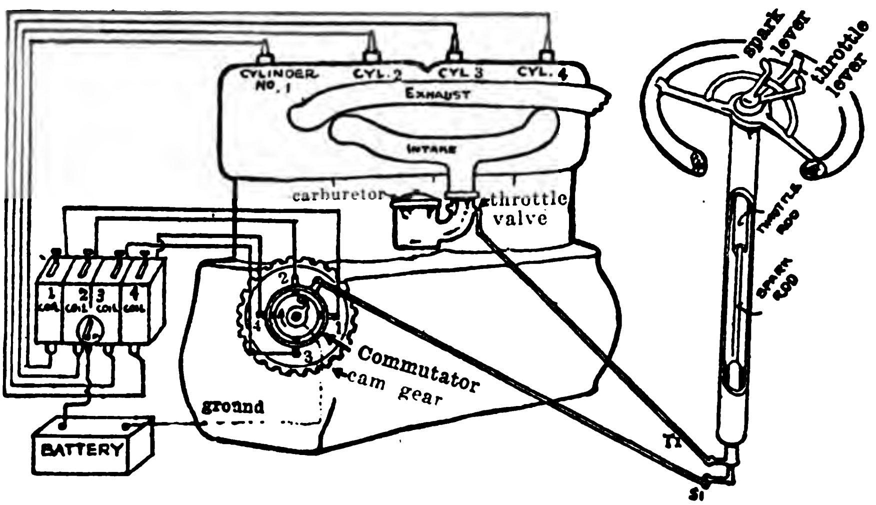


Fig. 6—Note the manual (hand) method of "advancing" and "retarding" the commutator. (Four cylinder engine as example.) If the roller is revolving to the right, by shifting the commutator housing to the left, contact would be made earlier—this would be called " advancing" the spark. If shifted to the right, would be made later—called "retarding."

When using a vibrator coil (which is the case here), the time of spark is set earlier than when using the single spark system—because plenty of time must be given the spark to ignite the gas so it will ignite or combust on top of the stroke instead of after the top. Note connections to commutator for firing order of 1, 3, 4, 2.)

HART NO. 106—The Commutator, Timer and Purpose of each. Commutator Control.

bove timer, fig. 3, is open-circuit type. The closed-circuit type per pages 242 and 378 is now in general come a magnet. It will also affect another wire placed alongside of the wire carrying the current. These same lines of force which will make a magnet out of a piece of soft iron will set up another current of electricity in another wire close to it, but which has no electrical connection with it.

That is, if we would take a coil of wire and attach the end of the coil to a battery and then wind another coil around this first one and insulate it from the first, we would find that every time the current in the first coil, that is, the one connected with the battery and which is called the primary coil is interrupted, or commences to flow or stops flowing, there is a current set up or "**induced**" in the other coil, which is called the "**secondary**" **winding**.

As long as the current in the first coil continues without change or interruption, it does not set up an "induced" current in the secondary coil, fig. 3.

The current is "induced" in the secondary coil only when the flow of current in the primary coil changes, usually by opening or closing the circuit. The effect of the primary coil upon the secondary has been found to be increased if we put a bar of soft iron inside the two coils (which is done in fig. 3). The construction is just the same as if we took the electro-magnet referred to in Fig. 2 and wound the secondary coil outside of the primary coil.

The secondary current acts in the same manner as the primary current; that is, it flows through wires and can be made to do work, and it can be grounded; the current leaving the secondary winding at one terminal and returning to the other. The difference is that it has exceedingly high pressure (voltage), and little volume (amperage), and flows in a reverse direction, while the primary current has low pressure and great volume, but in both cases the total currents are equal.

Therefore we have learned the first principles of a high tension coil; how the iron core is wound with a "primary" wire, and over the primary winding another winding called the "secondary," is wound.

When the circuit of the primary coil, which is connected with a source of electric supply of some sort, is closed and opened suddenly, the current is "induced" in the second winding, and at the same time it is "intensified," meaning, the voltage is raised so high it will jump a gap as shown in figure 3. **The method for making and breaking this contact at the right time**, will now be treated.

The Vibrator—its purpose.

As the secondary current only flows when the primary current begins to flow, and **is** suddenly interrupted, there must be an arrangement that completes the primary circuit, so that the battery current **stops flowing or is interrupted from flowing.**

This arrangement is called a "vibrator," and it may operate in two different ways; "**electrically or magnetically**," and "**mechanically**."

The Mechanical Vibrator.

The "mechanical vibrator," is shown in chart 105, fig. 2. When this type of vibrator is used, the **vibrator on the coil is not required,** as the vibration of the flat spring against the adjusting screw causes the contact to be suddenly opened and closed, by the cam, during which time the **flat spring vibrates mechanically,** causing an induced current to flow in the secondary winding of the coil.

It consists of a flat spring with a small weight on one end, and the other end is attached to a post. The weight rests on the iron rim of a small cam with a notch in it, so that when it turns the weight drops into the notch. One wire from the primary circuit is attached to the flat spring and the other wire of the primary to an "adjusting screw."

When the weight called the bob, is in the notch of the cam, the float spring makes contact with the "adjusting screw," and the current flows, but the cam in continuing to turn moves the weight out of the notch, which separates the flat spring from the screw, and breaks the circuit.

Because of the springiness of the flat spring, it **vibrates** when the weight drops into the notch, making and breaking the current. By making and breaking the contact in this way, the primary current flows through the primary winding in waves, flowing and stopping each time that the vibrator makes and breaks the circuit, which produces a corresponding current in the secondary winding, called an "induced" current, as previously explained.

The interruption method fig. 2, chart 105, **was used extensively on single cylinder motorcycle engines and a modification of this principle is used on the modern ignition systems,** as the Delco and Atwater-Kent systems, but instead of the flat spring, a different method is employed as shown in fig. 3 chart 106, which gives but a single spark. The principle of "mechanically" closing and opening the circuit, however, is similar. (See also pages 247 to 252 and 378.)

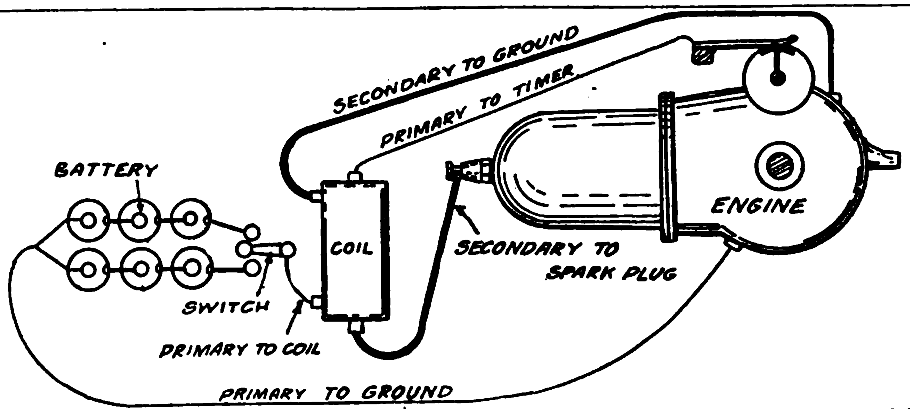


Fig. 1.—One Cylinder Engine with a Vibrator Type of Jump Spark Coil and Two Sets of Dry Batteries for Ignition. Only one set of batteries in use at the time. Commutator revolves one-half the speed of crank shaft.

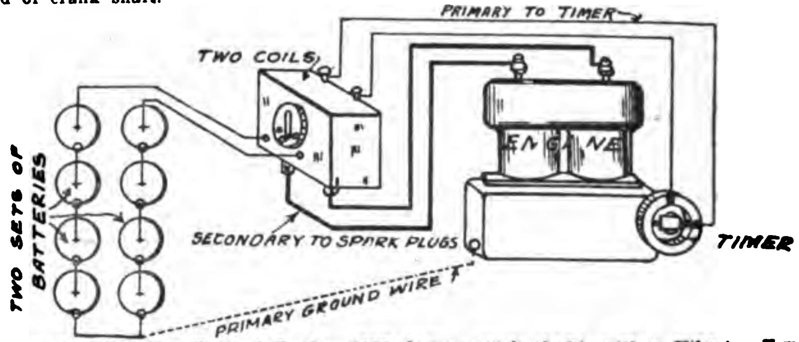


Fig. 2.—Two Cylinder Vertical Engine (180 degree crank shaft) with a **Vibrator Type of Jump Spark Coil and Two Sets of Dry Cells for Ignition.** Note position of segments on commutator. **Commutator revolves one-half the speed of crank shaft. (This type of engine is seldom used.)**

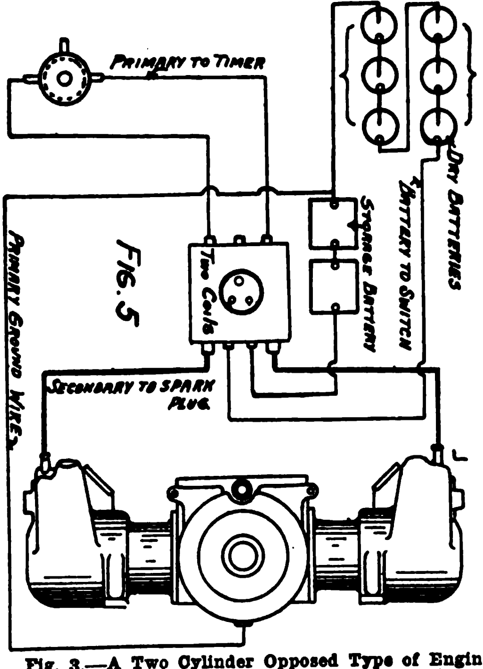


Fig. 3.—A Two Cylinder Opposed Type of Engine with a Two Cylinder Jump Spark Coil and a Set of Dry Cells and a Storage Battery, either of which may be used. The two contacts on commutator placed opposite. **Revolves ½ speed of crank shaft.**

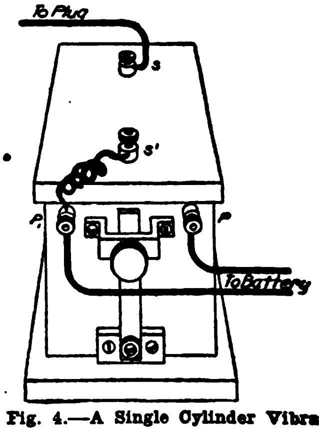


Fig. 4.—A Single Cylinder Vibrator Type of Jump Spark Coil. This type is usually called a "Box Coil." Quite frequently a single cylinder box coil has but one secondary connection on top. In this case the secondary connection shown at front of the coil is connected inside of the coil to the primary wire which connects to binding post P.

CHART NO. 107—Wiring Connections of the High Tension Vibrator Coil System of Ignition. (Magnetos not shown here).

The Magnetic Vibrator.

The magnetic vibrator depends on the magnetism produced in the core of the coil when the primary current passes. (See figs. 1 and 3, chart 105.) A flat spring, called the vibrator spring or blade, is so placed that one end of it is opposite the end of the core, the other end being firmly supported. Touching the vibrator spring near its free end is the point of contact with the "adjusting screw."

Connections: One terminal of the battery (fig. 1, chart 104), is attached to the adjusting screw; the vibrator spring is connected to one of the primary winding of the coil; the other end of the primary winding is connected to the commutator, which we will call a revolving switch. When the "commutator" switches the current through the primary winding the "core" becomes a magnet and attracts the free end of the vibrator spring, drawing it away from the adjusting screw. As soon as the attraction draws the vibrator spring out of contact with the adjusting screw, the circuit is broken; the current stops flowing in the primary coil, the core ceases to be a magnet, and the vibrator spring being no longer attracted by the magnetism, it springs back and again makes contact with the adjusting screw. This again closes the circuit, the vibrator spring is again attracted by the magnetism—thus the circuit through the vibrator spring and adjusting screw is broken and made again **as long as the commutator keeps the primary circuit closed** through its contacts.

The strength of the secondary current, and consequently the strength of the spark, depends on the correct adjustment of the vibrator spring by the adjusting screw As the construction of a coil is very delicate, it is not expected of the driver that he be a coil expert, but he **should** know how to adjust the vibrator properly.

Succession and Single Spark.*

The high tension coil using a magnetic vibrator in connection with a commutator (fig. 1, chart 104); causes a "**succession**" of sparks instead of a "**single**" spark. The disadvantage of this type of coil is the possibility of the vibrator platinum points sticking, consequently a missing of explosions. Another disadvantage is that it makes several weak sparks, the hottest one igniting the charge. This causes slow ignition. A good "single" hot spark has proven the most effective, as used on the Delco and Atwater-Kent systems, employing a mechanical type of vibrator; (fig. 3, chart 106 and page 247).

The Commutator.

Because the secondary current is only needed when it is time for the spark to pass and ignite mixture, the primary current is switched into the primary winding only once during two revolutions, (on a single cylinder engine), and the switching is done by a "commutator" or "timer."

Before proceeding further we will make a distinction between a commutator and a timer. Heretofore the word "timer" and "commutator" have been used to apply to the same device. Suppose we call the device which makes the contact by a brush or roller contact, as per figs. 1, 2 and 6, chart 106, a commutator. This device is always used in connection with a magnetic vibrator type of coil.

The Timer.

The timer, we will class as a mechanical method of causing the contact to be closed and opened, as per fig. 3, chart 106. This device makes a single spark and is generally used in connection with a **coil without a vibrator.**

There are two principles of the timer; one, where it is used to **open** the circuit which is otherwise always closed. This operates on what is termed **the closed circuit** principle. The opening of the closed circuit **interrupts** the flow—therefore it is termed "an interrupter" or "contact breaker," (see page 243).

The other, when it is used to **close** the circuit which is otherwise always open. This operates on what is termed the **open circuit principle**: (treated further on).

---

*See page 250.

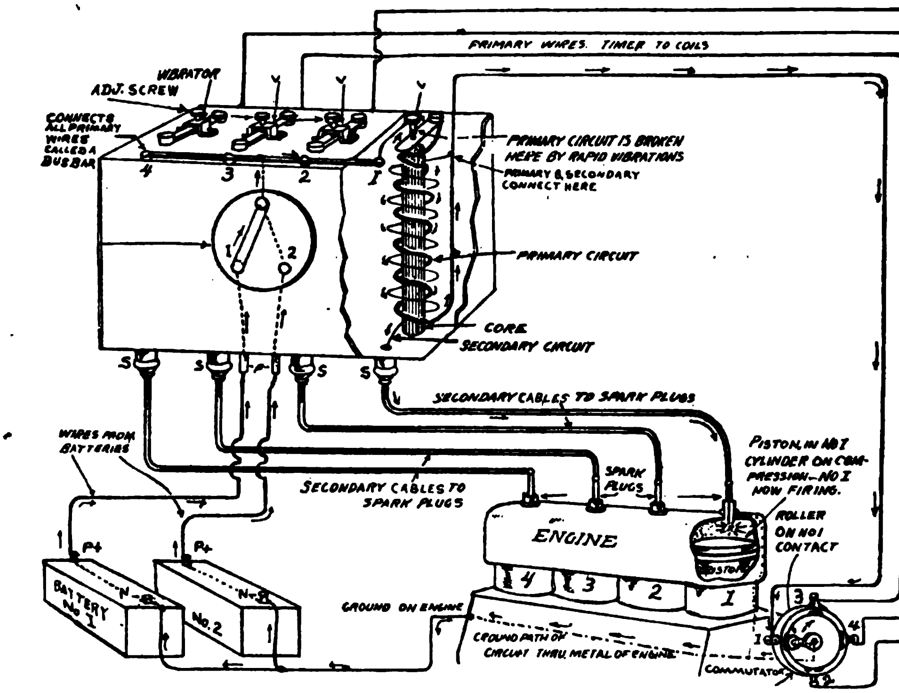

PRIMARY WIRES. TIMER TO COILS
VIBRATOR
ADJ. SCREW
V
V
V
CONNECTS ALL PRIMARY WIRES CALLED A BUSBAR
4
3
2
1
1
2
PRIMARY CIRCUIT IS BROKEN HERE BY RAPID VIBRATIONS
PRIMARY & SECONDARY CONNECT HERE
PRIMARY CIRCUIT
CORE
SECONDARY CIRCUIT
S
S
P
S
S
SECONDARY CABLES TO SPARK PLUGS
WIRES FROM BATTERIES
SECONDARY CABLES TO SPARK PLUGS
SPARK PLUGS
PISTON, IN NO 1 CYLINDER ON COMPRESSION—NO I NOW FIRING.
ROLLER ON NO 1 CONTACT
ENGINE
PISTON
4
3
2
1
P+
P+
BATTERY No 1
N-
No. 2
N-
GROUND ON ENGINE
GROUND PATH OF CIRCUIT THRU METAL OF ENGINE
COMMUTATOR
1
2
3
4

Fig. 1. Circuit of a Four Cylinder Vibrator Coil, Commutator and Storage Battery Ignition System.

This illustration will explain the wiring connection from the battery, through the entire coil, commutator, etc.

In order to clearly understand how the current travels and how the connections are made. **PLACE YOUR PENCIL** on the drawing at the (P·|·) positive pole of No. 1 battery and follow out the circuit.

We will begin with the positive pole connection of No. 1 storage battery; there are two batteries, but only one used at the time. If one runs down, the other one is thrown into service by switch on the coil. the switch is on No. 1 contact the circuit would be from No. 1 battery to switch, through switch lever to bus bar on front of the coil, which connects to the contact screw "V," thence through the platinum points. through the magnetic vibrator spring to the primary winding which is wrapped around a core or bundle of soft iron wires.

The other end of this primary wire connects with the segment on the commutator; the current is closed here at the right time. The commutator roller contact revolves as explained previously. When this contact is completed the primary circuit is closed on one of the four coils. When this circuit is closed, the bundle of iron wires (core) becomes magnetic and draws the vibrator down, but the moment the vibrator is drawn away from the contact with the vibrator screw, the circuit is broken and the vibrator springs back and makes contact again, but is immediately drawn down again; this, of course, is quick and rapid. This vibration is kept up as long as the contact is made on the timer, which, of course, is only for a moment, but during that time the vibrator makes several vibrations or "buzzes."

When these vibrations occur, the current is "induced" into the secondary winding of fine insulated wire wrapped around the primary winding, called a secondary winding or circuit. (How and why this current is induced into the secondary winding without any metallic connection was treated on page 221.)

This secondary winding, of course, has two ends; one end goes to a spark plug and the other end connects to one side of the primary wire, which grounds it through the timer back to engine, then to plug again.

A separate coil unit is provided for each cylinder. The duty of the commutator is to make contact at a certain time in order that the right coil will operate and supply an electric spark to the right cylinder at the right time.

Note: When one wire on any wiring diagram, passes over another wire without making contact, a half circle is made, as shown above, where wire to second coil jumps the two other wires.

HART NO. 108—Explanation of how a Four Cylinder Engine is Operated by Four Vibrator Co Units, Commutator and two Sets of Batteries. Note the firing order is 1, 3, 4, 2. Th change is made on the commutator.

ee also page 356 for electrical signs or symbols—of wires crossing, etc.

†**A commutator** might be termed a revolving switch which brings two pieces of metal, connected in the primary circuit in contact with each other as it revolves. One part of the commutator is stationary and the other movable, being attached to the half-time shaft (cam shaft). The usual location for a commutator on an engine, is on the end of the cam shaft, as shown in chart 106, fig. 6. (Also see Ford supplement.)

Construction: Commutators are made in various forms, some of which are shown in chart 106. (It is now seldom used.) The simplest, being one shown in fig. 1, consists of a small disk of hard rubber, wood fibre, or other insulator, in which is set a piece of metal that makes contact with the shaft to which the disk is attached. A flat metal spring, called a brush or blade rests on the circumference of the disk and as it turns the metal plate is brought in contact with the spring.

One wire from the primary circuit is connected to the brush; the shaft being of metal and resting in metal bearings, is in contact with the metal of the engine and consequently the electric current may pass from it to the primary wire that is grounded on the engine. Thus when the wheel has turned so that the piece of metal called a contact, makes connection with the brush (the brush or blade being insulated from the base), the current passes from the brush to the contact, to the shaft, and then through the metal of the engine back to the battery. As the wheel in continuing to turn moves the contact away from the brush, the circuit is broken and the current stops.

Each time that the contact touches the brush or blade, the battery current passes through the primary winding of the coil, making the vibrator operate and causing the secondary current to form its spark in the cylinder.

Commutator segments: The metal contacts in the fibre housing (fig. 2), to which wires from coils are connected, are called "segments." There are as many segments as there are cylinders. These segments are placed certain distances apart according to the number of cylinders, for instance; a "two cylinder" commutator would have two contacts; if it is of the opposed cylinder type. The two contacts would be placed 180 degrees apart. If a "single cylinder" engine, only one spark is necessary during two revolutions of the crank shaft, therefore the contact roller would revolve one-half the speed of the crankshaft and there would need be but one contact segment.

If a "four cylinder" engine, there would be four contacts; placed 90 degrees apart. Because the contact roller revolves one-half the speed of the crank shaft, there would be four sparks during two revolutions of the crank. If a "three cylinder" engine, the contacts would be 120 degrees apart. The roller contact also revolves one-half the speed of crankshaft in this instance. If a "six cylinder" engine the contacts would be 60 degrees apart, as six impulses or contacts are necessary during two revolutions of the crank shaft, therefore the roller contact would revolve one-half the speed of the crank shaft also. On an "eight," the contacts would be 45 degrees apart.

How the Commutator or Timer, Helps Control the Speed.

The commutator *is connected to the spark lever on the steering wheel. (See fig. 6, chart 106.) When the spark lever is pushed forward the commutator is shifted forward so that the metal roller makes contact earlier with the contact segment—this is called "**advancing**" the spark.

If the commutator is shifted back instead of forward, the contact is made later—this is called "**retarding**" the spark.

There are two methods for advancing and retarding the spark; (1) by hand, called "manual" method, per fig. 6, chart 106; (2) by a governor arrangement, as per chart 117, which is automatic. Both are explained under the "ignition timing" instruction.

The setting for the time of spark to occur is done by placing the contact at a certain position, as explained under "ignition timing."

The gas throttle lever is the lever used to run on and is the lever used to increase or decrease the speed of an engine. This is done by opening and closing the throttle, as explained under the subject of carburetors (see pages 67 and 68.)

It is well to run with the spark lever as well forward or advanced as possible, as it will tend to keep the speed of the engine up and consume less gasoline and create less heat. If the spark lever is too far advanced then the engine will pound or knock because the ignition will take place before the piston is over the center. **A retarded spark** produces heat—see page 319.

The amount of advancing and retarding of the spark by hand, must be learned by actual practice in order to get the best results.

**The Coil Condenser.

We have explained the essential principles of coil ignition; how the current is passed through the primary winding from a battery or dynamo; how the contact is made on the commutator and timer; how the flow of current is broken suddenly by means of a vibrator or timer and how the intensified spark is utilized for ignition.

---

†**Note—A commutator is really the segments on a dynamo** connected with the armature coils, and on which brushes rest. It really should never have been applied to the ignition, but is so well known as an early form of contact, hence we will use it as explained. The Ford uses what is termed a commutator. See page 225 for difference between a commutator and a timer.

*The advancing of the spark and relation of the speed of engine to the spark is treated under "ignition timing" also. **See pages 228 and 245 for coil condenser and page 273, magneto condenser.

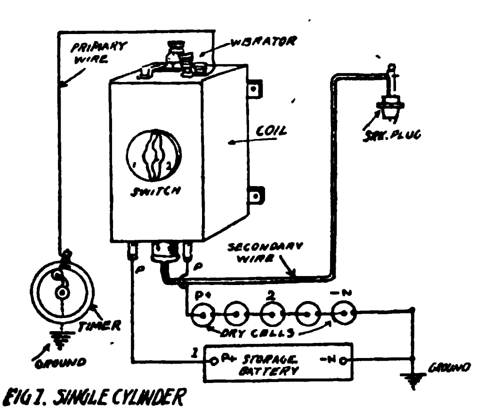


FIG 1. SINGLE CYLINDER

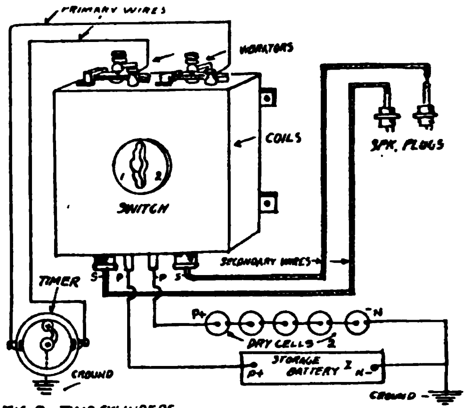


FIG 2 TWO CYLINDERS

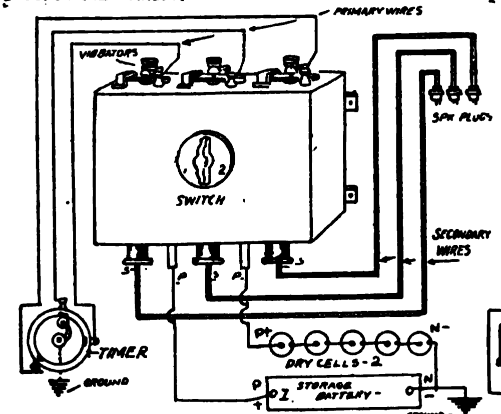


FIG 3. THREE CYLINDERS

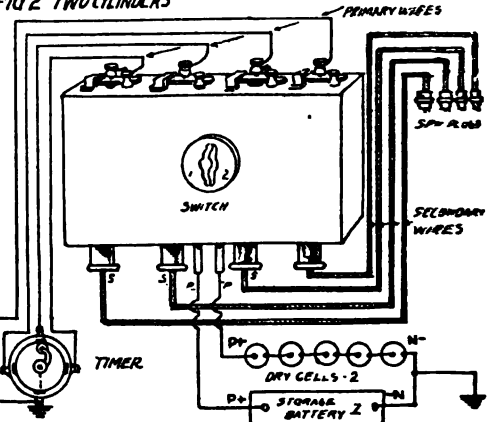


FIG. 4 FOUR CYLINDERS

The Condenser—below.

A condenser is connected with the primary circuit of all high tension coils with or without vibrators, also in connection with primary winding on high tension magnetos.

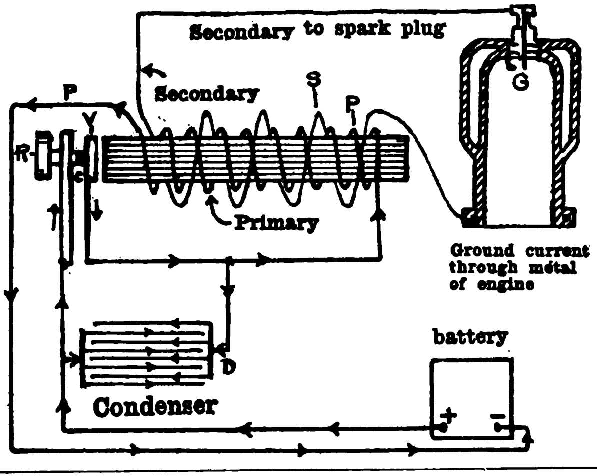
The purpose of the condenser is to intensify the spark at the points of the spark plug and also to prevent excessive sparking at the end of the platinum contact points (C) on the vibrator. If sparking at the vibrator is permitted to continue the point of the latter will wear and become pitted and will stick together.

A condenser is usually placed in the bottom part of the coil box and consists of a number of conductors, which in this case are leaves of tinfoil, separated by paper, covered with paraffine. Paraffine paper is usually employed, but mica or some other insulating material may be used.

The alternate layers of tinfoil are connected together and the remaining layers connected together as shown at (D). (see also page 229). The two terminals of the condenser are connected or "bridged" across the points (C) in the circuit as shown.

The function of the condenser is to act as a buffer to the current at the moment that the circuit at contact points (C) are broken. Its first duty, undoubtedly is to absorb the spark at the contact points.

Not only does the condenser absorb the spark from the contact points (C), but it reverses the direction of the current in the primary wire (P) and changes the poles of the magnet or core. For instance, end of core which was north pole of magnet suddenly becomes south and vice versa. versa.



The reason for it is this: We have seen that any change taking place in an electrical conductor induces electric currents in neighboring conductors, according to the intensity of the change. Now, the sudden change which is caused to take place in half the tinfoil of the condenser, when the current is broken by the vibrator blade (V), causes powerful currents to be induced in the other half of the sheets of tinfoil which are connected to the adjustable screw (R) and therefore to the primary winding; and as these induced currents flow in the opposite direction to the currents causing them they send a current through the primary in the opposite direction to the current that was flowing before the vibrator blade broke contact. Thus the current in the primary is not merely stopped but actually reversed. The effect being greatly to intensify the high tension current in the thin, secondary wire and therefore to produce a more powerful spark at spark plug (G). See page 273, magneto condenser.

CHART NO. 109—Diagram of Connections of the Splitdorf 1, 2, 3 and 4 Cylinder Vibrator Type of Coils. The coils are contained in a coil box and can be removed. Each coil is called a "Coil Unit." **A Condenser;** principle and connections. See page 803 for a "coil-box" and "

And now we come to the condenser which is usually built in the lower part of the coil where it is securely enclosed. Its functions are as follows:

We have seen that the intensity of the secondary current or spark depends upon the **suddenness** with which we can break the primary current and destroy the magnetic lines of force.

One might therefore imagine that the mere act of mechanically dividing the circuit would suffice, but it is not so, for this reason:—The effect of separating the contact points is mainly to induce a high-tension current in the secondary coil, but unfortunately this induction law does not confine its attentions entirely to the secondary winding, but proceeds to induce a high-tension "follow-on" current **in the primary coil itself**, thus defeating our efforts to get a sudden cessation of current here.

Not only so, but this current, having a high potential (i. e., is capable of jumping across air gaps), promptly makes a temporary arc between the points which have just separated. It therefore performs the double iniquity of (1) destroying the strength of the spark by preventing the primary current from stopping instantaneously and (2) of burning up the platinum points by the hot electric arc which is formed at the break.

We must therefore take steps to stop this and have accordingly, recoursed to the condenser.**

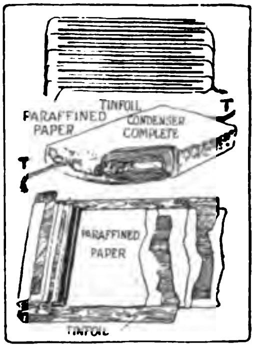


Fig 1—Construction of condenser

This is composed of a large number of small sheets of tin foil, insulated from each other by sheets of mica (or in the case of a coil by paraffin paper) and tightly pressed together. All the even numbers are connected up to form one pole, and all the odd numbers to form the other pole.

The condenser is "bridged" across the contact points C, fig. 5, page 228, or contact points of a magneto (page 274), in such a way that when the points separate, the condenser bridges the gap and acts precisely as a spring buffer. The high-tension "follow-on" is, so to speak, forced into the condenser, which on becoming charged instantly forces it out again by a species of electrical rebound not only checking the current but momentarily reversing its direction, which is of course even more effective.

The intensity of the secondary or firing spark is thus increased ten-fold and the primary spark at the contact points reduced almost to invisibility. (see also page 273.)

High Tension Coil Circuit.

The manner in which the parts of the high tension ignition circuit are connected together is shown on page 218, fig. 1. From the battery is led a ground wire, attached to any convenient part of the engine.

When the commutator connection on engine makes contact, the current flows from the battery (if a battery is used), from the positive (+) pole through the vibrator and the primary winding of the coil, through the contact segment of the commutuator, through the roller, and by the metal of the engine and the ground wire back to the battery at negative pole (N—).

As soon as the primary current causes the vibrator of the coil to operate, the "secondary" or "induced" current is formed, and goes to the spark plug, where it jumps the "gap" between the points, at "X" and returns to the coil through the metal of the engine and the secondary wire. We explained on page 221 how the current is "induced" from the primary winding to the secondary winding.

The usual trouble in the operation of the jump spark system is the fouling of the spark plug by carbon from a mixture that is too rich in gasoline, or by the burning of lubricating oil. This carbon deposit short circuits the points; that is, it is easier for the current to go from one point to the other by running over the carbon, which is a conductor, than by jumping across the gap on the plug. The result; engine misses explosion (see charts 112 and 113).

High Tension Coil—Wiring.

The following are examples of the high tension vibrator coil system of ignition, using a commutator. †The coil box is usually placed on the dash, but wherever its location may be, it should be carefully protected from moisture. The coil box contains as many coils as there are cylinders. Each coil is called a "unit."

Fig. 1, chart 107, page 224. Connecting a one cylinder engine with a high tension coil system; when the engine of an automobile has but one cylinder, it is usually placed in a horizontal position under the body of the car. The location of the battery, coil box or other parts of the ignition system depends on the design of the car.

*The switch is usually placed on the coil box. One wire from each set of batteries, usually from their positive poles, is connected to one of the switch terminals,

---

*In this illustration the positive (+) side is grounded, and the negative (—) side is connected to switch. However, it makes no material difference. In fact it is a good idea to occasionally change the flow of current, to prevent the platinum points of the coil "pitting" as explained under description of the Atwater-Kent Depolarizer Switch, chart 117, fig. 5.

†See page 803 for illustration of a "Coil-box" and "Coil-unit." **See page 228 fig. 5, and fig. 1, this page.

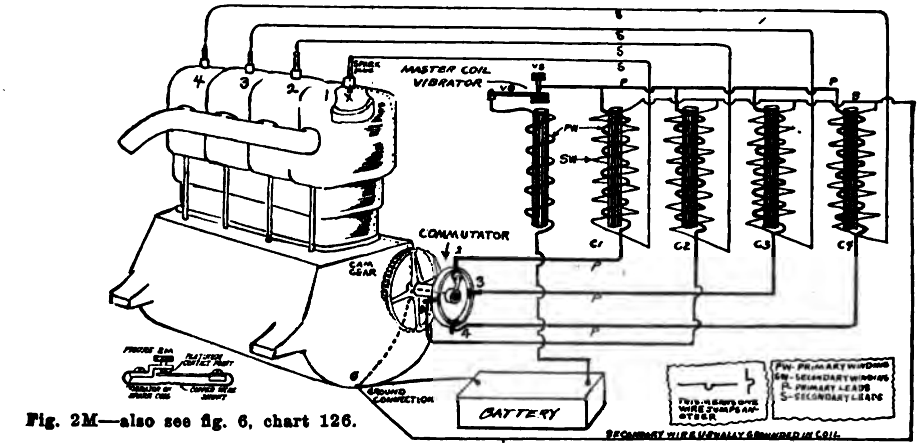


Fig. 2M—also see fig. 6, chart 126.

Fig. 1—A master vibrator coil on a four cylinder engine as an example. SW—secondary winding. PW—primary winding. P—primary wire. VB—vibrator. VS—vibrator screw. C—coils. BB—buss bar, connecting all primary windings at one end. SG—secondary ground wire. Fig. 2m shows how the vibrator on the coils C1, C2, C3 and C4 are short circuited.

The purpose of the master vibrator coil is to do the vibrating for the other coils.

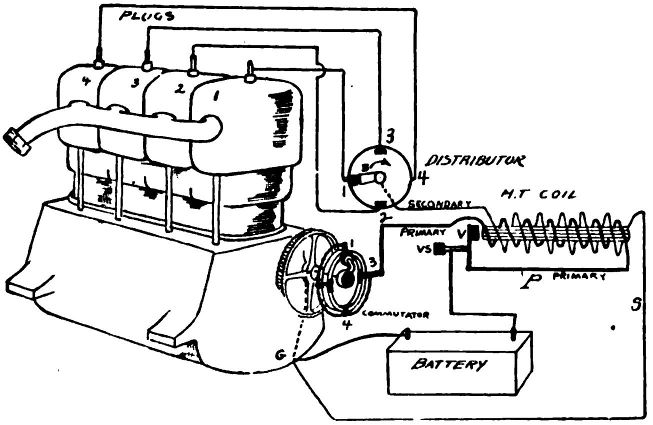
For instance; quite often multiple cylinder coils with several vibrators cause considerable trouble from the "sticking" or welding together of the platinum points, causing missing. Where a multiple unit coil is used, a great deal of care must be excercised to keep in proper adjustment.

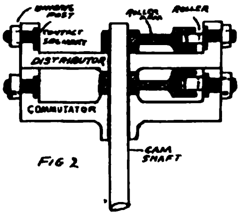
By placing a single wound master vibrator coil in series with the primary circuit, and by short circuiting all of the vibrators on the coils, the one master vibrator will do the work for the others.

It will be noted however, the other coils are used for making the spark otherwise. **Also** note there is but one winding on the master vibrator coil; its purpose merely being that of vibrating.

On the above diagram, note the firing order is 1, 3, 4, 2. No. 1 cylinder is now firing, as coil (C1) and contact on commutator (1) is in operation. The next cylinder to fire will be No. 3 Trace diagram with pencil.

Note all of the secondary wires are "grounded" on one end. This is usually done in the coil box, all connections being made to a binding post. A ground wire is then run to the frame of engine from the binding post.





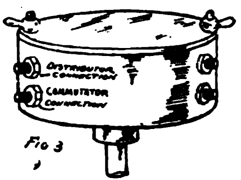


Fig. 1A—A high tension distributor or synchronous system of ignition. P—primary winding. S—secondary. Note one end grounds to engine; usually grounded on the coil. VS—vibrator screw.

Fig. 2—Note distributor and commutator are together. The wiring diagram shows the two separated merely to explain the action.

A distributor system uses but one vibrator coil. Thus doing away with a great deal of complicated wiring. Instead of a commutator being placed on the end of cam shaft, a combination of a commutator and distributor as shown in Fig. 2, is placed there. When one makes contact, the other does also (this is called synchronously, or meaning at the same time).

The purpose of the distributor is to distribute the secondary current to each spark plug at the right time. Note No. 1 is now on contact on commutator, also on distributor. No. will fire next. (See text.) Note all the terminals are connected together on the commutator.

HART NO. 110—A Master Vibrator High Tension Coil Ignition System. A High Tension Distributor or Synchronous System. (Note the master vibrator system would also be termed a synchronous system.)

See page 264 for K. W. Master-vibrator.

so that swinging the switch blade from side to side throws one or the other into circuit. The negative terminals are grounded by being connected to the metal of the engine, using one wire for both.

The primary terminal of the coil box is connected to the binding post of the commutator; when the commutator in revolving makes contact, the current flows through the shaft to which the commutator is connected and through that and the metal of the engine to the ground wire and battery. Thus the only primary connection to be made are from the two sets of batteries to the switch; from the batteries to the ground; from the primary binding post to the commutator. The secondary terminal of the coil box is connected to the spark plug.

Fig. 2, chart 107, page 224: Two cylinder engine with high tension vibrator coil, using two sets of dry cells: The coil box contains two coils, one for each cylinder and is usually located on the dash. The box containing the batteries is usually under the seat.

The connections from the batteries to the switch are the same no matter how many coils there may be; that is, each set is connected to a switch point. and one ground wire for both.

The commutator has two binding posts, one for each contact point and one primary terminal is connected to one of the contacts, the other primary terminal being connected to the other contact. In the commutator shown in fig. 2, chart 107, the crank is supposed to be 180 degrees, which in chart 52, fig. 3, was shown to produce two power strokes in one revolution, followed by a revolution without a power stroke. The contact points of the commutator are separated by a distance that requires the crank shaft to make a half revolution or 180 degrees, in order that the moving part may move from one contact to the other, or 90 degrees, and then a revolution and a half to move it to the first contact point again. This, of course, is uneven firing. The placing of the segments on commutator therefore must be 90 degrees from first to the second segment, then 270 degrees to the next (commutator revolves one-half speed of engine crank).

If the crank shaft of this vertical engine were 360 degrees, as in engine fig. 2, chart 52; the contacts would be on opposite sides of the commutator like the commutator shown in fig. 2, chart 109, so that the crank shaft would make a full revolution to turn the moving part from one to the other, because a crank shaft of this kind permits a power stroke every revolution. Because a horizontal two cylinder opposed engine permits a power stroke every revolution. this last described commutator is also used on it. (fig. 3, chart 107.)

Fig. 1, page 226: Four cylinder engine with a high tension vibrator coil system, using two storage batteries: The more satisfactory system for a four cylinder high tension vibrator coil system of ignition (we will make exception of the magneto and Delco, Atwater-Kent and systems of this kind, which are treated later), is with a storage battery as shown in fig. 1. One battery is used for regular work, the other for a reserve. Or a set of dry cells could be used as a reserve. The wiring of a four cylinder vertical engine is the same in principle as that of engines with fewer cylinders, there only being an increase in the number of parts.

It must be remembered that, for reasons given in chart 53, the order in which the explosions occur in the cylinders is not **regular**, 1, 2, 3, 4, but **irregular**, being 1, 3, 4, 2 or 1, 2, 4, 3. While either of these may be used according to the action of the exhaust valve, the former, 1, 3, 4, 2, is in most general use as the engine is considered to run with less vibration than with any other firing order; therefore, we will connect this commutator and coil for a firing order of 1, 3, 4, 2.

The wiring connection for this irregular firing, is made by changing the connections on the commutator, causing the spark to occur in the proper cylinder at the right time.

Referring to fig. 1, chart 108, it will be seen that **connections are made between the primary terminals** of the coil box and the commutator, so that the current of No. 1 coil leads to the contact on the commutator which makes connection to cylinder No. 1, which is now at the end of the compression stroke and ready to fire.

As the commutator revolves, the next contact to be made is No. 3, on commutator which is the next cylinder to fire. Cylinder No. 4 fires third; therefore coil No. 4 is connected to the next commutator contact to be made. The next cylinder to fire is No. 2; therefore No. 2 will fire after No. 4.

The connections between the **secondary terminals** of the coil box and the spark plugs are in regular order; coil No. 1 to spark plug No. 1, coil No. 2 to spark plug No. 2, and so on.

It must be understood that the proper connections are made in the coil box by makers to permit the secondary current to return to the secondary winding over the commutator and ground wire. In fig. 1 this connection is made inside of coil where it says, "primary and secondary connect here."

The Master Vibrator Coil.

With the "high tension" vibrator coil system, just described (chart 108, page 226); as many coil units, each with vibrators, would be provided as the engine had cylinders. If a four cylinder engine; four vibrator coil units would be necessary. If a six cylinder engine; six vibrator coil units would be necessary.

It will be noted that with this number of vibrators, one or more would be constantly sticking, unless a great deal of attention was given to them.

Therefore, by using a **master vibrator, only one vibrator coil is used,** which is connected with the other coils as shown in fig. 1, chart 110.

The master vibrator coil has but a **single primary winding,** and is connected in series, so the primary current must travel through it before reaching any of the coils. The usual commutator is employed.

The master vibrator coil can be connected with a "multiple" of coils, by **screwing down the vibrators** on all coils and short circuiting them by connecting as shown in fig. 2M, page 230 and fig. 4, page 264. **Note** the coils are the regular double wound, **high** tension coils, as shown on pages 220 and 226.

The advantage of such a system is that there is but one vibrator to keep in adjustment, since this vibrator serves for **all** the cylinders; whereas, with one for each unit, all have to be kept in adjustment and the difficulty of keeping several adjustments is a considerable factor.

The disadvantage is the great amount of wiring necessary with the multiple coil system. Although the master vibrator is easily connected and requires very little wiring, the "distributor" system which will be explained next requires considerably **less** wiring. The master vibrator is an excellent addition to be applied to a multiple system of ignition, already installed.

*The "Distributor" or Synchronous System of Ignition.

In the foregoing examples it will have been noted that the amount of wiring required for engines having more than one cylinder becomes increasingly complicated. A system now generally used, known as the "**distributor system,**" very considerably simplifies the wiring, and at the same time more accurate timing of firing of the respective cylinder is obtained. (See fig. 1A, chart 110.)

One tremble coil only, is necessary, this having the high-tension terminal joined up to the "distributor," which is a special form of rotating switch highly insulated, which directs the high-tension current to the cylinders in the required order.

The distributor brush (B), rotates at the same speed as the commutator roller contact maker, and in perfect unison with it; that is to say, when the low tension circuit is completed, the high tension circuit is completed likewise. The diagram should make the system clear, it being borne in mind that the distributor is rotating as well as the contact maker, and in perfect "**synchronism**" with it.

The secondary distributor is made in combination with a commutator, each with as many contacts as the engine has cylinders and with the moving parts of each attached to the same shaft and revolving. (See chart No. 110, figs. 2 and 3.)

The battery is connected to the single coil in the usual manner, and a wire is run from the primary terminal of the coil to the commutator, where it is connected to the four points. Thus when the commutator revolves, the current is passed through the one coil every time that contact is made.

If with this arangement a wire was run from the secondary terminal of the coil to the four spark plugs, sparks would pass in all four cylinders whenever the timer made contact. Instead of this, one secondary wire is run from the secondary terminal to the moving part of the distributor, and from each contact point of the distributor to the proper spark plug.

When the commutator makes contact, and the secondary current is formed, it flows to the distributor, which at that instant has made contact with one of the points, so that th secondary current flows across the contact and to the spark plug that is connected.

The advantage of this system is that there is only one vibrator to keep in adjustment, and fewer parts. The **disadvantage** is that the coil has no rest, and the constant use tends to heat it, and destroy its insulation. The constant action of the vibrator is liable to burn the vibrator points, and destroy them.

Therefore the modern ignition system,* using a "distributor system" of a similar principle, as the Delco and Atwater-Kent systems; the "vibrator" is not used. The timer being of slightly different construction obviates the necessity of the vibrator. This latter system is explained further on in this instruction.

---

*The principle of this system is similar to Delco and Atwater-Kent modern battery and coil ignition systems, except the systems mentioned, use a form of timer, called an "interrupter," thereby dispensing with the vibrator on the coil—(treated separately farther on).

INSTRUCTION No. 18.

SPARK PLUG AND COIL TROUBLES: Spark Plug Tests and Gaps. Size of Spark Plugs; Regular, A. L. A. M. or S. A. E. Testing Coils and Spark Plugs. Ignition Wiring Troubles. Dressing Platinum Points.

Inasmuch as we will deal next with **coil ignition systems without the vibrator**, it is well to review the troubles caused by vibrators and their relation to the spark plug. We will also refer to troubles caused by defective wiring, commutator, etc.

When the engine stops, one or more of the following, is likely the cause; (1) out of gasoline; (2) carburetion defective; (3) ignition defective.

Under the subject of "carburetion" will be found the carburetion, gasoline and kindred troubles and remedies.

If the trouble is not with the carburetion, then the trouble is likely due to ignition. The following may be the cause; broken or loose wire or switch, run down **battery.**

*****If the engine misses explosion**—the trouble may be due to carburetion at fault (see carburetion). If the trouble is not with carburetion, then **the chances are the spark plug is missing** on account of being fouled. The spark plug causes more trouble in this respect than any other part of the ignition system. (see pages 218 and 237.)

The cause of spark plug sooting and pre-ignition: †A poor grade of oil will turn to carbon (soot), and will deposit on the end and inside of the spark plug and "short circuit" the plug so that the spark will not occur at the point and consequently cause missing of explosion.

Poor oil will also leave carbon or soot deposit on the end of the piston and inside of the combustion chamber. This deposit hardens, and sharp points of it will project. This projection will become heated white hot, causing the gas to ignite before it is time. This is called premature or "**pre-ignition.**"

Therefore, spark-plug troubles are usually as follows; short-circuited from carbon, cracked porcelains, electrodes burnt away, not pressure tight, moisture condensing on insulator.

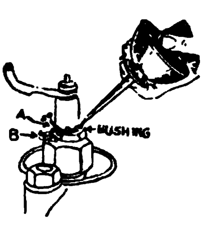
*Spark Plug Tests and Gap.

To test to see if the spark plugs are missing, see page 237, figs. 1 and 2. Another method, if a vibrator coil is used, is explained in fig. 1, page 236.

To see which spark plug is missing, see pages 237 and 236.

To test the spark plug itself, see fig. 2, page 236.

To see if spark plug is leaking around the porcelain at the top (A) of bushing or below (B) where bushing is screwed into the shell of plug — squirt gasoline at these points, engine is running and note if bubbles appear.



Plug Gap.

The gap is the distance between the points on the plug shell and electrode (see fig. 3, page 218), It is important that this distance be exact.

‡A magneto requires less gap on plug than a coil, because when engine is running slow, the magneto current is weaker.

‡Where a vibrator coil is used, the usual distance is about 1-32 inch. **With a "single spark" system,** however, as the Atwater-Kent, where the spark is very quick the gap must be very small, about .025 of **an inch.** In fact this is the **average distance.**

It is also essential that the battery be kept charged so it will deliver its proper voltage with a "single spark" system—as it is quick and must have pressure enough behind the coil to cause a hot spark.

††If points are too close, it will be impossible to run slowly, for the actual area of the flame will be too small.

††If gap is too wide, misfiring (on a high compression engine) is apt to take place, especially when one tries to accelerate suddenly, after going slow. The effect of opening throttle and admitting a full charge is to increase compression and it is well known that resistance increases with pressure.

The coil will operate up to 1/32 inch, but bear in mind the greater this distance, the more strain on coil and "leaner" the spark.

The space between the spark points must be considered an insulator, and it must be remembered that the compressed charge in the cylinder through which the spark is required to jump is a better insulator than uncompressed air.

A spark that will jump the point or gap of a spark plug when the plug is out of the cylinder may not have strength enough to jump when the plug is screwed in the cylinder and under compression. So the spark must be especially strong, and should be able to punch a hole through a visiting card held between the points.

Therefore the gap depends upon; (1) the kind of ignition system; (2) the amount of compression of engine.

---

†See repair subject, "pre-ignition and carbon removal" pages 689 and 623. *Location of the spark plug is usually over the inlet valve, see page 219. Also see page 239 for size of spark plug for different cars.

***See page 171. ‡See pages 299, 298, 297, 808. ††See also page 250.

Adjusting Vibrators.

The usual way of adjusting a coil trembler or vibrator is the rather rule-of-thumb method of screwing down the trembler screw till there is a sharp musical "buzz" obtained, and, as near as it is possible to determine, to adjust the screws so as to obtain the same note from each trembler.

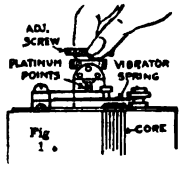


Fig 1.

Current consumption of the coil depends largely on how close the vibrator contacts are set. Very often it happens that a good deal of current is wasted in having too close contact, and at the same time the platinum points on both the vibrator and the adjusting screw are soon "pitted" and worn out from the excessive sparking.

There is a further serious disadvantage; insomuch that the firing point cannot be synchronized for each cylinder, the closely-set trembler firing the charge earlier than the lightly-set one, and thus it happens that an engine rarely gives off the full amount of power. Perfect synchronism is required in obtaining full power. This explains why some engines often give more power on the magneto. The fault lies in bad setting of the coil and sticking vibrators.

*Testing a Vibrator Coil.

A special ammeter reading very low (0 to 3 amperes), for adjusting coils is a most useful accessory, as it is only necessary to connect it in the primary coil circuit, one terminal being joined direct to the terminal on the coil, and the other joining to the battery terminal, the usual connection being temporarily taken off. (see fig. 2.)

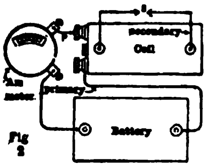


Fig 2

A 6 volt fully charged storage battery or four fresh dry cells can be used.

Separate the secondary terminals (S) ¼ inch.† Adjust vibrator until needle on ammeter shows 1¼ amperes.

If there is a continuous flow of blue sparks and there is volume to the spark instead of being yellow and thin, then the coil is well adjusted and is o. k. Try blowing on the spark to see if it spreads, this indicates volume, which is desirable.

If the flow of sparks is not constant, this indicates that the vibrator points are probably "pitted."

If there is a short circuit in the coil, or points stuck, the needle would go far beyond its normal range, indicating the passage of excessive current.

If there is a bad connection inside of coil, the needle would jump about instead of remaining steady.

A loose terminal or connection would cause a low and unsteady reading.

If ammeter shows over 1.8 amperes, the coil may be wound for a higher amperage than 1¼, and if adjustment of screw does not reduce same, then the vibrator spring is too strong and stands away too far from the core. In this case bend the vibrator spring down and readjust screw.

A light contact on a coil trembler means economy of current, but if too light the engine will not run properly; above a certain speed it will be weak as the result of a feeble spark at the plug.

Dressing Platinum Points.

Every time the contact separates, a minute quantity of platinum is transferred from one contact to the other. If the current is reversed by means of a reversing switch, the lost platinum will be transferred back to some extent. This is called depolarizing. Therefore, when using "direct" current for vibrator coil ignition, it is a good idea to occasionally change the connection on the battery. The current flowing in one continuous direction causes this pitting of points. Where "alternating" current is used, as with a magneto, the points do not pit as much, because current is changing direction of flow.

Testing Platinum Contact Points.

Imitation platinum will also cause "pitting." You can test to see if genuine platinum by putting nitric acid on it. If it eats into the metal it is not genuine platinum. A jewelers-stone can also be used for this test—ask any jeweler.

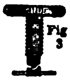


Fig 3

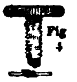


Fig 4

Fig. 3 shows pitting, and is the state a properly set contact-point finally arrives at.

Fig. 4 is the result of a badly-set contact, which is worn unevenly, the platinum would have to be filed away right down to the steel and the spark would then soon eat the rivet hole and cause serious misfiring.

Dressing Contact-Points.

To dress the platinum points, remember that the main requirements are to remove only as small amount of the valuable metal as possible and trim the surface dead level and smooth, and in making the final adjustment of the screw, do not set the platinums closer than necessary to give a good, steady buzz of the vibrator.

For dressing the points (also magneto points), suitable small jewelers files are sold at accessory shops. It is a very thin and finely cut file.

If surfaces are merely blackened insert a strip of 00 emery paper between the two points, and pull the paper through them a few times.

An oil stone is excellent for dressing points—see page 809.

Platinum and Tungsten Contact-Points.

Insist on genuine platinum points when purchasing new screws or vibrator springs. Platinum-iridium and Tungsten metal points are both used. Imitation points will "pit" and burn together and cause missing.

Platinum iridium alloy, which consists of 80% platinum and 20% iridium, should be used on all **magneto contact-breaker points.** Pure platinum would hammer under action of interrupter, therefore iridium which is harder is used with it.

Tungsten points are quite often used on coil and battery systems due to its extreme hardness and infusibility, but its disadvantages for magneto use are oxidation of points when heavy currents are carried. The oxidation results in a high resistance oxide which makes it difficult to start, and the arcing makes it very difficult to distinguish when a condenser is defective. When platinum iridium contacts are used, extreme arcing is always an indication of a defective condenser. Tungsten points therefore require a greater condenser capacity to overcome arcing than platinum does.

Platinum iridium is best for all contact points but as stated, tungsten can be used on coil and battery systems—see also page 304.

Above applies to contact points on vibrator coil screws and springs.

Spark Gap Suggestions.

Do not set spark plug gaps over 1/32 inch apart. A longer gap will likely cause a misfire.

When testing the spark, by removing wire from plug, do not separate the terminal wire from plug or engine frame more than ⅜ inch, as it will strain the coil and break down the insulation.

CHART NO. 111—Adjusting Vibrators. Dressing down "Pitted" Platinum Points.

On the Ford, the magneto generates "alternating" current, therefore, the pitting of points is not so bad, but when the car is run continuously at high speed, naturally the magneto generates a higher voltage, hence pitted platinum points. (See Ford Supplement.) †See page 739 for a simple method of arranging a handy gap when testing. *See also, pages 302, 398.

Setting Gap of Spark Plug.

First set gap at .025—if engine misses, then try this; remember that the gap should be just as wide as the ignition system will stand.

To experiment—try setting the plug point on say—one cylinder until it misses on a hard pull up hill with throttle closed or as much closed as it will pull the hill comfortably.

Then slightly close gap and try hill again and continue experimenting in this way until the missing stops. When correct distance is found then set the other plugs accordingly.

Spark Plug Construction.

Location—usually over the inlet valves on "L" type cylinders and on the side, of "I" head cylinders. See page 219, why spark plugs are placed over inlet valves.

Where plugs are used on **overhead valve** engines or high compression engines the plug must be of **good** construction—**gas** tight and free of electrical leaks—and are usually placed on side of engine (see Buick).

Construction—There are two types in general use; the "**separable**" type plug where the insulation or core can be removed as per figure 3, page 218, and the "**integral,**" or one piece plug per figs. 5, and 10, page 238.

The parts of a plug are; the **shell** or body which screws into cylinder (see 3, page 218); the **insulation** which is held in the shell by **brass bushing** (N); the **electrode** which passes through insulation. **Washers** are used as a gas tight packing, per fig. 2, page 218.

The **insulation** is sometimes made of mica, but owing to the construction, which is usually with washers, it leaks or permits current to pass to the electrode especially when oily. **The best insulation is porcelain** and this, unless of best grade (not porous)* will also leak, thereby weakening the spark.

Where mica is used on plugs on aeronautic engines, per fig. 12, they are used but a brief time and new ones substituted.

†**Separable plugs have tendency to leak and cause missing**, especially at low speeds and hard pulls or on high compression engines. The **integral** plug appears to gain a point in its favor here.

Electrode should be made of nickel alloy—if not properly made it will expand under intense heat and break the porcelain.

Cement—is placed around electrode—as it dries, it becomes porous and porosity means electrical leaks.

Therefore, it is plain to see that "leakage of gas" and "leakage of electricity" are the troubles to be overcome in spark plug construction. Leakage of gas causes "**leakage of compression**" and leakage of electricity causes a "**weak spark.**"

Poor throttling, poor pick up, missing on hard pulls and high speeds are frequently caused by using a poor grade plug. Of course there are other conditions which will cause this, (see page 171), as carbonized insulators, or too close or too wide a gap at the plug points, or improper carburetion adjustment, but assuming that these troubles are corrected the leakage of gas and electricity are two essentials seldom noticed.

Therefore, the highest priced plug is often the cheapest. Likewise a poor grade coil when hot, will lose its efficiency.

Spark Plug Sizes.

Different threads are explained on page 238. **Different lengths**, see page 237 and 238.

Cleaning a Spark Plug.

Don't mar or glaze the porcelain as it will cause "**porosity**" and "**electrical**" leaks. See pages 237, 592.

**Vibrator Coil Troubles.

We will not deal with the modern "single spark" coil troubles here but principally with the vibrator type coils. The single spark coil is dealt with further on.

Vibrator points sticking; where the vibrator type of coil is used. This is frequently the cause of missing of explosion. The points burn together as explained on page 234. The cause of this, is due to the "direct" current flowing in one direction continuously. (see page 248, "depolarizer switch.") Another cause is that of using too much pressure or voltage. For instance, coils are usually wound for 6 volts. If each dry cell gives 1¼ volts when working, and five cells used, the coil points do very nicely. If, however, eight cells are used, the excess pressure is more than the condenser in coil can take care of; result excessive sparking at the platinum points on vibrator and screw.

To test the vibrators, see chart 112. **To adjust** vibrator and clean the platinum points, see chart 111.

‡**Other causes of missing**, as before stated, is due to loose wires or connections on battery or run down battery—see page 241 for loose connections and wiring and for testing batteries.

**To test a high tension coil, see page 236.

*See "Standard Adjustments of Leading Cars," for gap to set spark plugs.

**See index, "Testing Coils."

‡See pages 299, 298 and 297—for magneto interrupter adjustment. See pages 298 and 171 for missing at low and high speeds.

†Separate plugs should have good gaskets and drawn tight—see page 239.

*Its difficult to obtain a porcelain which will not absorb oil and cause leakage of electricity through it. Best grade come from France and Bohemia.

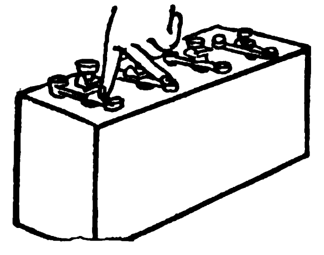


Fig. 1—Testing for missing with vibrators on the coil.

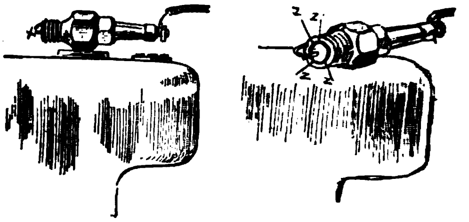


Fig. 2—Testing a Spark Plug.—Place the spark plug on the cylinder with wire connected and switch on. Crank engine slowly. If the spark occurs at the gap "X" the plug is O. K. If it sparks up inside of the shell, between the porcelain and shell at "Z," it is fouled and misses. It must then be taken apart and carbon removed.

Causes of Spark Plug Missing.

The cause of missing of explosion is usually due to the spark plug becoming fouled by carbon, soot depositing on the porcelain insulation, causing the plug to become short circuited. Generally caused by using a poor grade of oil or loose piston rings, which permits the oil to pass too freely into the head of cylinder.

Other causes are sticking vibrator points as explained on page 234.

When starting to test, for the trouble, **first** determine if the missing occurs when running slow or when running fast, or if at all times. Also be sure the carburetion is right.

Testing for Miss with Vibrators.

We will assume the engine is a four cylinder engine.

To ascertain which, if any of the four plugs are fouled with oil, short circuited with carbon or inoperative from some other cause, open the throttle two or three notches to speed up the engine; now hold your two fingers on two outside vibrators so that they cannot buzz. The evenness of the exhaust will show that the other two are working correctly and that the trouble is not there; or an uneven exhaust will indicate that it is between the two that are free.

If the two cylinders fire evenly change the fingers to the two inside vibrators and again listen to the exhaust. Having ascertained in which pair the trouble is, hold down three fingers at a time until you find the one which does not fire.

Cylinder No. 1, we will say, is the front cylinder, and they number in rotation 1, 2, 3, 4. No. 1 coil unit would be the one farthest from the steering post (left side drive) and they number 2, 3, 4 to the left.

Testing Spark Plug.

Then remove the spark plug and test the plug as shown in fig. 2. If the plug is O. K., then you know the trouble is not in the plug. If plug is not O. K., then clean it or put in a new one.

Remember the plugs may spark in the open air, but when under compression fail to spark, because the resistance is greater. Therefore, be sure the points are not over 1⁄32 of an inch apart at the extreme, for vibrator coil use.

Vibrator Coil Cause of Missing.

In rare instances one of the coil sections will become short circuited or insulation become punctured on the secondary winding. Caused by using too many batteries or too high a voltage. In this case the plug would not spark at all, therefore it would be advisable to try changing positions of the coil units in the box, if the plug sparks O. K. **on one** of the other coil sections, then you may **know that** particular coil unit is defective. **Therefore, inspect the platinum points on the vibrators and contact points,** as they may be partially burned away or badly pitted if this coil section still fails to give a spark, then it is evident it is burnt out inside.

In some instances a coil may have its insulation short circuited for only half its length of winding and would give a spark. If short circuit was near the beginning of winding it would not spark at all. See page 416. See page 241, for testing for a broken wire.

Testing the Coil.

If multiple cylinder engine, test each unit separately until it is determined which coil is missing. After assuring yourself the missing is not caused by a spark plug, weak batteries, carburetion, or other causes, then test the coil itself, as explained above, see also pages 249 and 253 for testing the modern non-vibrator coil.

On a non-vibrator type coil, the spark could be tested up to a jump of ½ inch on a test—continuously.

On a vibrator coil, ⅜ inch. Don't place the distance further, as it is likely to damage coil.

To test a magneto—see index. **To test for a broken wire**—see page 241. **To test for grounds and short circuits**—see index.

Other Causes of Missing.

When mis-firing occurs, particularly when running at high speeds, it would be advisable to inspect the commutator, as the fibre may be worn so that the roller touches only the high spots, or it may be that the roller has worn out of round and consequently forms imperfect contact on all of the points.

At slow speeds, is apt to be the result of improperly seated valves or air leak in the carburetor or cylinder head gaskets.

A weakness in compression may be detected by lifting the starting crank slowly the length of its stroke for each cylinder in turn. In rare instances an exhaust valve may become warped by the engine becoming overheated, in which case the valve seat will have to be reground or the valve replaced.

Other causes of missing explosion is due to weak batteries, therefore test the batteries as explained on page 241.

CHART No. 112—Missing of Explosion; Source of the Causes.

The coil in this instance is the old style vibrator type and matter refers principally to the vibrator coil and commutator system. The spark plug test is applicable to all systems.

Finding the Missing Spark Plug.

Fig. 1—Relief cock test: Open the relief cocks, one at a time. Watch for the flame shooting out of each opening and listen for the sharp reports of the explosions. The cylinder without flame, out of which issues only a hiss, but no sharp report is the one at fault.

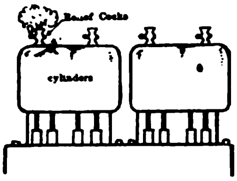
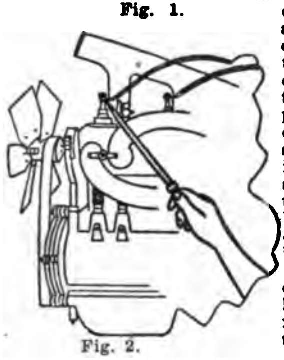


Fig. 1.

Fig. 2—Another method is that of short circuiting one plug after another. This may be done by holding a screw-driver or other instrument so that it will make connection between the head of the spark plug and some part of the engine. When short circuiting, note if engine seems to slow down, if so, that plug is O. K. If there is no difference, then the plug is likely at fault. Hold the screw-driver by its wooden handle, else you may receive a shock from the ignition current.



Spark Plug Location.

Usual location is in neighborhood of inlet valve, which is correct, as it should be surrounded by fresh gas that enters during inlet stroke. If located on exhaust side dead gas will collect about plug electrodes and cause missing.

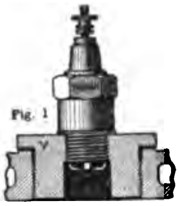


Fig. 1: Valve cap too thick—out of path of gas.

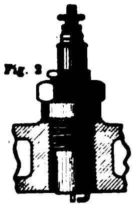


Fig. 2: Recess around plug shell retains heat.

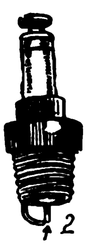
It is also desirable to have plug where water jacket surrounds it, as in fig. 4, to avoid overheating, else plug electrodes are liable to become overheated and become incandescent and cause pre-ignition.

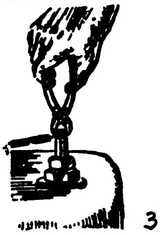
Poor location is shown in fig. 1. When set in a thick valve cap (V) with short threads, dead gas accumulates in recess and causes missing at slow speeds. Fig. 2 shows another poor method. The recess accumulates heat and metal extension is liable to become red hot and warp electrodes altering size of gap.

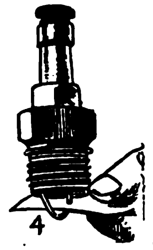
Good location is where spark plug points or electrodes just reach the combustion chamber where cool fresh gas will come in contact and flame will spread with maximum rapidity as in figs. 3 and 4.

When plug extends too far in combustion chamber there is danger of valve head striking it.

Spark plug lengths — see page 238.







Spark Plug Causes of Missing.

Fig. 1—Missing may be caused by the spark arcing from shell to the terminal—cause: porcelain too short and gap too wide at points.

Fig. 2—Points may have come together—cause: screwing plug into cylinder bent points together.

Fig. 3—Wire may have become loose from terminal—cause: terminal not screwed down tight.

Fig. 4—Shows method of adjusting the distance between the points of the plug; distance should be about 1/32 of an inch apart for coil ignition, and 1/64 of an inch for magneto ignition .025 average.

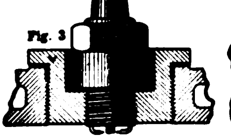
To test for a missing spark plug; first, open the relief cock to each cylinder, as shown in fig. 1. If a blaze emits from the relief cock, then the cylinder is firing. It is advisable, however, to see that it fires regularly. The missing may not be in the plug at all and a slight movement of the adjusting needle valve one way or the other on carburetor will remedy the trouble. If the missing IS in the PLUG, then it must be cleaned.

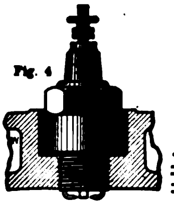
When an engine begins to misfire suddenly, from some unknown cause, the first thing a driver should do is to note whether the firing is regular; that is if it occurs in only one or two cylinders at regular intervals in the cycle of explosions; or, if it is intermittent in one cylinder or in different cylinders.

A regular misfire in one cylinder, that is, misfiring that occurs once at the same time in every cycle of the engine, generally is caused by a defective plug or a disconnected high-tension wire. A defective valve also is probable.

Intermittent misfiring in one cylinder may be due to a defective plug or loose terminal connection or a valve that is not closing tightly.

Other causes of missing are: Worn timer, loose connection, platinum points on coil or magneto, spark plug, carburetor needle valve and auxiliary air valve need adjusting; air leak around intake; battery weak.





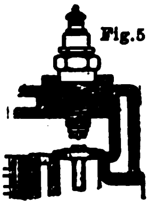


Fig. 3: Correct position of plug in valve cap.
Fig. 4: Correct position when set in water jacket.
Fig. 5: Plug reach too long, liable to strike valve.

*To Clean Spark Plug.

If the trouble is suspected of being a short-circuited plug, due to carbon, etc. (see page 238), unscrew it and clean it as follows:

To clean a spark plug: Unscrew the bushing which holds the porcelain in the shell, remove the porcelain (or mica) and soak the shell and porcelain in kerosene or gasoline. Clean all carbon off each. Don't scrape porcelain, as it will roughen the glazed part and cause it to retain carbon. If the oil is burnt on the porcelain, muriatic acid will remove it. In placing the porcelain back into the shell, be sure the copper washer is placed back and bushing screwed tight to prevent leaking.

If then impossible to get a spark at the plug, when laid on cylinder, then start inspection by testing batteries as shown on pages 241 and 450.

If still unable to obtain a spark, then examine the connections on the battery; one of them may be loose or broken under the insulation or not soldered to the copper connection, as shown in fig. 6, page 241, or connection to **storage battery terminal** may be loose.

If trouble is not now removed, then trace the wiring from the batteries to the coil. See if the wires have been allowed to get next to the hot exhaust pipe; if this is the case, make a metal "T" joint, as shown in fig. 11, page 241.

All terminals should be carefully inspected and all connections soldered.

The ground wire fig. 4, page 241, should be carefully cleaned and scraped, as well as the part of frame it is grounded with and drawn tight.

If wires are suspected of being broken, see index "testing for open circuit."

CHART NO. 118—Testing for Missing Explosion. Spark Plug Troubles, cause and remedies.

---

*Alcohol is also suitable for cleaning plugs, see also page 592.

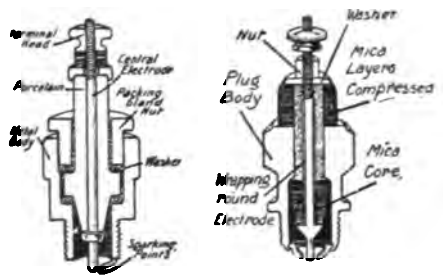


Fig. 10M.

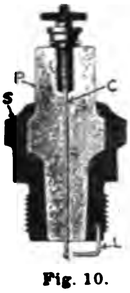


Fig. 10.

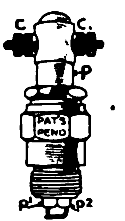


Fig. 11.—Double spark plug—shell is not grounded. P1 and P2 are separate porcelain insulators.

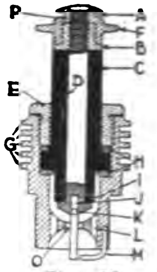


Fig. 12.

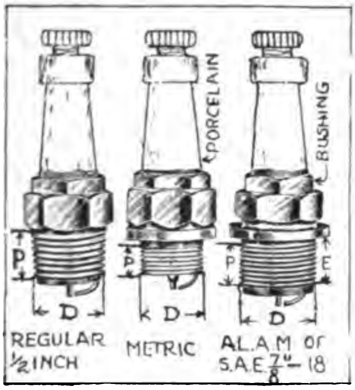
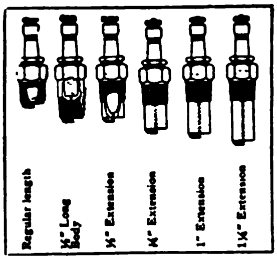
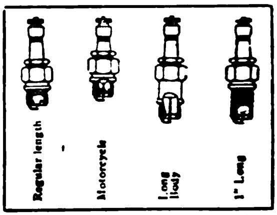


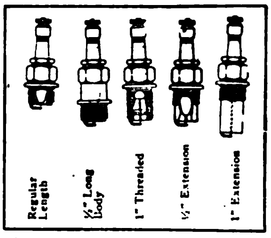
Fig. 4: Regular length of ½ in. Metric, and ⅞ in. spark plugs.



½" Pipe Thread Models



Metric (18 m/m) Models



⅞"-18 (S. A. E. Models)

Spark Plug Threads.

Spark plugs are made with three standard threads —see fig. 4; the ½ inch pipe thread; ⅞-18 S. A. E.; and Metric.

The ½ inch size is a thread which is a **standard** ½ inch iron pipe size **and** has a slight taper.

The ⅞-18 size, is the size which was adopted as a standard by the Society of Automotive Engineers, for automobile use. It was formerly known as the A. L. A. M. The thread is ⅞ inch in diameter, **with 18** threads to the inch (see page 703, 612 and 705). It is used on a majority of the cars today.

The metric size is smaller than either of the **above**. Its diameter is 18 millimeters or approximately $1\frac{1}{16}$ **inch**. This is the size thread for spark plugs, adopted by the Society of Automotive Engineers for **aeronautic engines**. It is also used on the Packard, Pierce and many **motorcycles**. It is used extensively abroad.

Integral, or one-piece spark plug, see also fig. 10 & 10M.

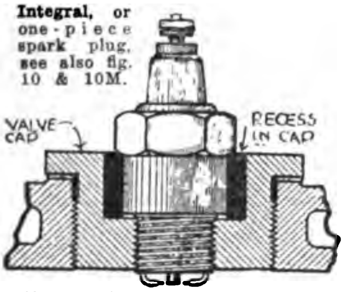


Fig. 5: Note long body to raise the hexagon part of plug above the recess in the valve cap so a wrench can be applied. Different kinds of valve caps require different lengths of plugs. (see page 237.)

Spark Plug Lengths.

The length of a spark plug depends upon the engine it is used on. If the valve cap in engine is deeply recessed as in fig. 5, a **long body** plug is required, otherwise the wrench could not reach **the hex**. **If** on the other hand, it was not recessed, a **long thread** would be required. **If however**, the valve cap plug should not screw well down into combustion chamber, then **an extension** is required, for it is important that the points of the plug extend to the combustion **chamber**. It is well to note here however, that the plug points must not extend too **far—see fig 4**, page 237. This extension, of course, depends upon the distance the plug is to **extend, therefore** they are made with ½ inch and 1 inch extension. By referring to above **illustrations** this will be made clear.

Aeronautic Spark Plug.

Fig. 12: Aeronautic type spark plug is designed for great heat and high compression. **Type shown** in fig. 12. It is of mica construction and very costly to construct. Note the **heat radiation flanges on** shell. Also baffle plate, (O) which tends to keep oil from the mica, stem (P) made of **brass or copper** for heat conductivity, electrode (J) is swedged at bottom of stem (K). Core is **mica washer sections (I)** with a mica insulation tube at (D). **Usual gap opening is .015".**

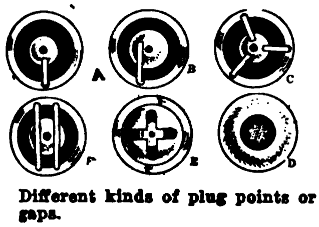
ART NO. 118A—Spark Plug Sizes Explained.

page 612 for S. A. E. **spark plug shell** and page 705 for size taps to use for spark plug **threads. For** k plug wrenches, see pages 611 and 612.

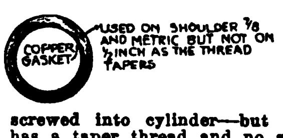
Name	Size and Model Plug
Abbott	⅞" 18 Regular Length
*Abenaque	½" " "
*Acme, M. T.	⅞"-18 " "
Adams, M. E.	½" " "
Adams, M. T.	½" & ⅞"-18 " "
Advance Rumely T.	⅞"-18 " "
Ajax	⅞"-18 " "
*Alford, E.	½" " "
Allen	⅞"-18 ½" Ext.
*Allis Chalmers, M. T.	½" ½" Ext.
Alter	⅞"-18 Regular Length
Anderson, M. E.	½" " "
Anderson, M. T.	⅞"-18 " "
Apperson	½" & ⅞"-18 " "
Arbenz	½" & ⅞"-18 " "
Armleder, M. T.	⅞"-18 " "
*Atlas, E.	⅞"-18 " "
*Atlas, G. E.	½" & ⅞"-18 " "
Atterbury, M. T.	⅞"-18 " "
Auburn	⅞"-18 " "
Aultman-Taylor, T.	½" " "
*Austin	⅞"-18
*Autocar	⅞"-18 " "
Available, M. T.	⅞"-18 " "
Avery, T.	⅞"-18 Regular Length
Barker, M. T. & M. E.	⅞"-18 " "
Bates, T.	½" 1¼" Ext.
Bauer, E.	½" Regular Length
Bauroth	½" " "
Beaver, E.	½" & ⅞"-18 " "
Bell	Metric " "
*Bessemer, E.	⅞"-18 ½" Ext.
Bessemer, M. T.	⅞"-18 & ½" Regular Length
*Biddle	⅞"-18 " "
Blair, M. T.	⅞"-18 " "
Brennan, E.	Metric " "
Brill, E.	½" " "
*Brintnell	½" & ⅞"-18 " "
Briscoe	⅞"-18 " "
Brockway, M. T.	⅞"-18 " "
Brooks, M. E.	½" " "
*Brown, E.	½" " "
*Buckeye, T.	½" " "
*Buckeye	⅞"-18 " "
*Buckeye, E.	½" " "
Buda, E.	⅞"-18 & ½" " "
Buffalo, M. E.	⅞"-18 ½" Ext.
Buick	⅞"-18 ½" Ext.
*Bull, T.	½" Regular Length
Cadillac	⅞"-18 " "
Cody, M. E.	½" & ⅞"-18 " "
Caille, M. E.	½" " "
Cameron	½" " "
Campbell, M. E.	½" " "
Capitol, E.	½" & ⅞"-18 " "
Case	⅞"-18 " "
Chalmers	⅞"-18 ½" Ext.
Chandler	⅞"-18 Regular Length
Chase, M. T.	½" & ⅞"-18 " "
Chase, E.	½" " "
Chevrolet	⅞"-18 " "
Christensen, E.	½" " "
*Clay, E.	½" " "
Clifton, E.	½" & ⅞"-18 " "
Clyde, M. T.	⅞"-18 " "
C. O. D., T.	½" " "
Cole	⅞"-18 " "
Collier, M. T.	⅞"-18 " "
Columbia, M. T.	⅞"-18 " "
*Commerce, M. T.	½" & ⅞"-18 " "
Commercial, M. T.	½" " "
Continental, E.	⅞"-18 " "
*Corbitt	⅞"-18 Regular Length
Coupler-Gear, M. T.	⅞"-18 & Metric " "
*Crescent, M. E.	⅞"-18 " "
*Croce, M. T.	½" & ⅞"-18 " "
Crow-Elkhart	⅞"-18 " "
Crown, M. T.	½" & ⅞"-18 " "
Cunningham	⅞"-18 " "
Curtis, Ae.	Metric " "
Cushman, E.	Metric " "
Daniels	⅞"-18 " "
Darracq	Metric " "
*Dart, M. T.	½" & ⅞"-18 " "
*Davis, E.	½" & ⅞"-18 " "
De Dion	Metric " "
DeKalb, M. T.	⅞"-18 " "
Denby, M. T.	⅞"-18 " "
Denning, T.	⅞"-18 " "
Detroit, M. T.	⅞"-18 " "
Deyo, Macey, E.	½" & ⅞"-18 " "
Diamond, M. E.	½" " "
Diamond, T., M. T.	⅞"-18 " "
Dodge	⅞"-18 " "
Doman, M. E.	½" " "
Domestic, E.	½" ½" Ext.
Dorris	⅞"-18 Regular Length
Dort	⅞"-18 " "
*Drexel	⅞"-18 ½" Ext.
Dusenberg, M. E.	⅞"-18 Regular Length
Durable Dayton, M. T.	⅞"-18 " "
Duplex, T.	⅞"-18 " "
Duryea, Gem	½" " "
Eagle, M. C.	Metric Motorcycle
Eagle, M. E.	½" Regular Length
Eclipse, E.	⅞"-18 " "
Elgin	⅞"-18 " "
Elgin, E.	½" " "
Elco, E.	⅞"-18 " "
Elk, M. T.	½" & ⅞"-18 " "
Ellis, E.	½" " "
*Elmira, M. T.	½" " "
Empire	⅞"-18 " "
Enger	⅞"-18 " "
Erd, M. E.	½" & ⅞"-18 " "
Erie, M. T.	½" & ⅞"-18 " "
Evansville, E.	½" " "
Ever Ready, E.	½" " "
Evinrude, M. E.	½" & ⅞"-18 " "
*Excelsior, M. C.	Metric Motorcycle
Fairbanks-Morse, E.	½" Regular Length
*Falcon, M. T.	½" " "
Famous, M. T.	½" ½" Ext.
*Fargo, M. T.	⅞"-18 Regular Length
Farmack	⅞"-18 ½" Ext.
Federal, M. T.	⅞"-18 Regular Length
Ferro, M. E.	½" " "
Fiat (American)	⅞"-18 " "
Fiat (Italian)	Metric " "
*Field-Brundage, E.	½" " "
*Fifield, E.	½" " "
Foos	½" & ⅞"-18 " "
Ford	½" Long Body
Ford	½" Priming Plug
*Ford, T.	½" ½" Ext.
*Foreman, M. E.	½" Regular Length
Fostoria	⅞"-18 " "
*Four Drive, T.	⅞"-18 & ½" " "
*Four Wheel Drive, T.	½" & Metric " "
Fox, M. E.	½" " "
Franklin	⅞"-18 " "
Frisbie, M. E.	½" ½" Ext.
Frontenac, M. T.	½" Regular Length
*Gede, E.	½" " "
Garford, M. T.	⅞"-18 & ½" " "
General, M. T.	⅞"-18 " "
G. V. (Gas)	⅞"-18 " "
*Gersix	⅞"-18 " "
Gleason, E.	½" " "
Globe, M. T.	⅞"-18 " "
G. M. C., M. T.	⅞"-18 " "
Golden, Belknap & Swartz, E.	½" & ⅞"-18 " "
Gramm-Bernstein, M. T.	⅞"-18 " "
Grant	⅞"-18 " "
Gray, M. E.	½" " "
Great Eagle	⅞"-18 " "
Great Western, M. E.	½" " "
Great Western	⅞"-18 " "
Hackett	⅞"-18 " "
Hall, M. C.	⅞"-18 " "
Harley-Davidson, M. C.	⅞"-18 " "
*Harms, G. E.	½" & ½" ½" Ext.
*Harriman, Ae.	½" Regular Length
Harvey, M. T.	⅞"-18 " "
Happy Farmer, T.	½" " "
*Hawkeye, M. T.	⅞"-18 ½" Ext.
Haynes	⅞"-18 Regular Length
Heider, T.	⅞"-18 " "
Henderson, M. C.	½" " "
*Hendrickson, M. T.	⅞"-18 " "
Herff-Brooks	½" " "
Herschell-Spillman, E.	½" & ⅞"-18 " "
Hewitt, M. T.	Metric " "
*Hobart, E.	½" " "
*Hoke, T.	⅞"-18 " "
Holliday, M. E.	½" " "
Hudson	⅞"-18 " "
Hupmobile	⅞"-18 " "
Hurlburt, M. T.	⅞"-18 " "
Hub, M. T.	⅞"-18 " "
I. H. C., M. T.	½" & ⅞"-18 " "
*Ice, M. T.	⅞"-18 " "
Ideal, E.	½" " "
Imperial	½" " "
Independent, M. T.	½" & ⅞"-18 " "
Indian, M. C.	Metric & ⅞"-18 Motorcycle
Indiana, M. T.	⅞"-18 Regular Length
*Ingersoll Rand	½" " "
*International, M. T.	⅞"-18 & Metric
Inter-State	⅞"-18 Regular Length & ⅞"-18 ½" Ext.
Isotta-Fraschini	Metric
Jackson	⅞"-18 Regular Length
Jeffery	⅞"-18 " "
Jones Six	⅞"-18 " "
Kanawha, M. T.	½" & ⅞"-18 " "
Kelly, M. T.	⅞"-18 " "
Kearns Kar	Metric " "
Kearns, M. T.	⅞"-18 " "
Kermath, E.	½" " "
Kemper-Odee, E.	½" " "
Kensington, M. E.	½" " "
Kerrihard, E.	½" " "
Keystone, E.	½" " "
*Kelly-Springfield, M. T.	⅞"-18 " "
*Kelly-Springfield Road Roller	½" 2" Loop Ext.
King	⅞"-18 Regular Length
Kissel Kar	⅞"-18 " "
*Kline Kar	⅞"-18 " "
Klaiber, M. T.	⅞"-18 " "
Knickerbocker, M. T.	⅞"-18 " "
Knox, M. E.	½" " "
Knox	⅞"-18 " "
Koban, Inboard Motor	½" " "
Koban, Rowboat Motor	⅞"-18 " "
*Koehler, M. T.	⅞"-18 " "
Krebs, M. T.	⅞"-18 " "
Krit	½" " "
*Kuehl, E.	½" & ⅞"-18 " "
Lackawanna, M. E.	½" ½" Ext.
Lamb, M. E.	½" " "
*Lansing, E.	½" " "
Lange, M. T.	⅞"-18 " "
Larrabee-Deyo, M. T.	½" " "
Lauth-Juergens, M. T.	⅞"-18 " "
LaZier, E.	⅞"-18 & ½" " "
Lewis	½" " "
Lexington	⅞"-18 " "
Liberty	⅞"-18 " "
Lincoln, M. T.	⅞"-18 " "
*Lion, T.	½" " "
Lippard-Stewart, M. T.	⅞"-18 " "
*Little Giant, M. T.	⅞"-18 & ½" " "
Locomobile	⅞"-18 " "
*Longest, M. T.	½" " "
Lozier	⅞"-18 " "
*Luitweiler, Fire E.	½" " "
Lyons, E.	½" " "
Maccar, M. T.	⅞"-18 Regular Length
Mack, M. T.	⅞"-18 "
Madison	⅞"-18 Regular Length
Mais, M. T.	⅞"-18 " "
Marion-Handley	⅞"-18 " "
Marmon	⅞"-18 " "
Martin, M. T.	⅞"-18 " "
Marvel, M. C.	Metric Motorcycle
Maxwell	⅞"-18 Regular Length
Maxwell (up to 1914)	½" " "
*Mason	½" & ⅞"-18 " "
Mason, M. E.	½" " "
Meyer, T.	½" " "
McFarlan	⅞"-18 " "
*McIntyre	½" & ⅞"-18 " "
McLaughlin-Buick	⅞"-18 ½" Ext.
McKay	⅞"-18 Regular Length
Mecca	½" " "
Menominee, M. T.	⅞"-18 " "
Mercury, M. E.	½" " "
Mercedes	Metric, 1" Long
*Mercer	⅞"-18 Regular Length
Merkel, M. C.	Metric Motorcycle
Metz	½" 1¼" Ext.
*Mianus, M. E.	½" Regular Length
*Michigan Steel Boat	½" " "
*Miller, E.	½" & ⅞"-18 " "
Mitchell	½" " "
Modern, M. T.	⅞"-18 " "
Mogul, M. T.	½" & ⅞"-18 " "
Moline-Knight	⅞"-18 " "
Moline	⅞"-18 " "
Monitor	½" " "
*Moon	⅞"-18 " "
*Moore, T.	½" " "
Monroe	⅞"-18 " "
Moreland, M. T.	⅞"-18 " "
Moore, M. T.	½" & ⅞"-18 " "
*Morristown, M. E.	½" " "
Moyer	⅞"-18 " "
*Mullins, M. E.	½" " "
National	⅞"-18 " "
National, M. T.	⅞"-18 " "
*Nelson & LeMoon, M. T.	⅞"-18 " "
New England, M. T.	⅞"-18 " "
New Way, E.	½" " "
*New York Yacht, M. E.	½" ½" Ext.
*Nichols & Shephard	½" ½" Ext. & ⅞" Regular Length
Norwalk	½" & ⅞"-18 " "
Novo, E.	½" " "
Oakland	⅞"-18 " "
*Ohio, E.	⅞"-18 & ½" " "
Oldsmobile	⅞"-18 " "
Old Reliable, M. T.	⅞"-18 " "
Original, E.	½" " "
Oshkosh, E.	½" " "
Oswald, E.	½" " "
*Otto, E.	⅞"-18 " "
Overland	½" ½" Ext.
Owen Magnetic	⅞"-18 Regular Length
*Owen-Schoeneck	⅞"-18 " "
Packard	Metric " "
Packard Twin Six	⅞"-18 " "
Packard, M. T. Chain	Metric " "
Packard, M. T. Worm	⅞"-18 " "
Paige	⅞"-18 " "
*Palmer-Meyer	½" " "
Palmer-Moore, M. T.	½" ½" Ext. &
Peerless, G. E.	½" Regular Length
Peerless	Metric & ⅞" 18 Regular Length
Penrose, M. T.	½" " "
*Perkins, Wind Mill	½" " "
*Perkins, M. E.	½" " "
*Perkins, E.	⅞"-18 " "
Phianna	⅞"-18 " "
Pierce-Arrow	Metric & ⅞"-18 " "
Pierce-Budd, E.	½" ½" Ext.
Pilloid	⅞"-18 Regular Length
Pilot	⅞"-18 " "
Pioneer	½" & ⅞"-18 " "
Polo	½" " "
*Portsmouth, E.	½" 1¼" Ext.
Premier	⅞"-18 Regular Length
*Princess	⅞"-18 " "
*Pullman	⅞"-18 " "
Racine-Truscott, M. E.	½" " "
Rabaco	½" " "
Read, E.	Metric " "
Reading-Standard, M. C.	Metric Motorcycle
Red Wing, M. E.	½" & ⅞"-18 Regular Length
Regal	½" " "
*Reid, E.	½" " "
Reliable, M. T.	½" " "
Renault	Metric " "
Reo	½" ½" Ext.
Republic, M. T.	½" Regular Length
Republic	⅞"-18 " "
Rex	½" " "
*Richmond, E.	½" & ⅞"-18 " "
*Rippley, M. E.	½" " "
*Roberts, M. E.	½" & ⅞"-18 " "
*Roberts, Ae.	⅞"-18 " "
Robinson, M. T.	⅞"-18 " "
Ross 8	⅞"-18 " "
*R. S., M. E.	½" ½" Ext.
Rollins, E.	½" Regular Length
*Rowe	⅞"-18 " "
Royal, M. T.	⅞"-18 " "
*Rush, M. T.	⅞"-18 " "
Russell	⅞"-18 " "
Rutenberg	⅞"-18 " "
S. G. V.	⅞"-18 " "
*Sandow, M. T.	⅞"-18 & ½" " "
Sandusky, M. T.	⅞"-18 " "
Sandusky, T.	⅞"-18 " "
Sanford, M. T.	½" & ⅞"-18 " "
Saxon	⅞"-18 " "
Schacht, M. T.	⅞"-18 " "
Schaefer, E.	½" " "
*Schmidt, G. E.	½" " "
Scripps-Booth	⅞"-18 & Metric Regular Length
Seagrave, F. E.	⅞"-18 " "
Selden	⅞"-18 " "
Service, M. T.	⅞"-18 " "
*Shaw, M. C.	½" & Metric Motorcycle
*Sieverkropp, E.	½" Regular Leng
*Simplex	Metric, Long Body
Simplex, T.	½" Regular Leng
Signal	⅞"-18 " "
South Bend, M. T.	⅞"-18 " "
Spacke, M. C.	Metric Motorcycle
Spaulding	⅞"-18 Regular Leng
Speedway, M. E.	½" " "
Standard, M. E.	⅞"-18 " "
Stanley, G. E.	½" " "
Staver	⅞"-18 " "
Stearns	⅞"-18 ⅞" Ext.
Stegeman, M. T.	⅞"-18 Regular Leng
*Steiner, E.	½" " "
Sterling, E.	⅞"-18 " "
Standard, M. E.	⅞"-18 " "
Stanley, G. E.	½" " "
Staver	⅞"-18 " "
Stearns	⅞"-18 ⅞" Ext.
Stegeman, M. T.	⅞"-18 Regular Leng
*Steiner, E.	½" " "
Sterling, E.	⅞"-18 " "
Sterling, M. E.	½" Regular Leng
Sterling, M. T.	⅞"-18 & Metric " "
Sterling Roadster	⅞"-18 " "
Sternberg, M. T.	½" " "
Stevens-Duryea	⅞"-18 " "
Stewart, M. T.	⅞"-18 " "
Stork, M. E.	½" " "
St. Mary's, E.	½" " "
Studebaker	½" " "
Stutz	⅞"-18 " "
Sultan, E.	½" " "
Suburban, M. T.	⅞"-18 " "
Sun	⅞"-18 " "
*Termaat-Monahan	½" " "
Thomas	⅞"-18 " "
Thor, M. C.	Metric Motorcycle
Thompson, E.	½" Regular Leng
Tiffin	⅞"-18 " "
Toledo, M. E.	½" " "
*Transport, T.	⅞"-18 " "
Traverse, E.	½" " "
*Trebert, E.	½" & ⅞"-18 " "
Trojan, M. T.	½" & ⅞"-18 " "
Truscott-Pierce, M. E.	½" " "
*Turner-Fricke	⅞"-18 & ½" " "
*20th Century, E.	½" " "
United, E.	½" " "
United, M. T.	⅞"-18 " "
United Four Wheel Drive, M. T.	Metric " "
United States, M. T.	½" & ⅞"-18 " "
Universal, M. T.	⅞"-18 " "
Universal Tractor	⅞"-18 " "
Universal, E.	Metric " "
*Universal, M. E.	½" " "
Utility, M. T.	⅞"-18 " "
Veerac, M. T.	½" ⅞" Ext.
Velie	⅞"-18 Regular Leng
*Vim, M. E.	⅞"-18 & ½" " "
*Vulcan, E.	½" " "
*Vulcan	⅞"-18 & Metric " "
Wagenhals, M. T.	½" & ⅞"-18 " "
Wallis Tractor	⅞"-18 " "
Walter, M. T.	Metric " "
*Warner, E.	½" " "
Warren, E.	½" " "
Warren, M. T.	⅞"-18 " "
Waterman, M. E.	½" " "
Waterloo, G. E.	½" ½" Ext.
*Watkins, E.	½" Regular Leng
Weidely, E.	⅞"-18 " "
*West Chester, E.	½" " "
Westcott	⅞"-18 " "
*Western, E.	½" " "
*Westman, E. & T.	½" " "
White, M. T.	Metric & ⅞"-18 " "
White, G. E.	½" " "
Wichita Falls, M. T.	⅞"-18 " "
Wilcox, M. T.	⅞"-18 " "
Willet, M. T.	½" ½" Ext.
*Willingham, M. T.	⅞"-18 ½" Ext.
Willys	⅞"-18 Regular Leng
Willys-Knight	⅞"-18 " "
*Wisconsin, E.	½" " "
Wisconsin, M. T.	⅞"-18 " "
Wilson, E.	½" " "
Winton	½" ½" Ext
Winton, E.	½" Regular Leng
Wizard	⅞"-18 " "
*Whitcomb, E.	½" " "
Woods-Mobilette	⅞"-18 " "
Yale, M. C.	Metric Motorcycle
York, E.	½" Regular Leng
Zimmerman	½" " "

Abbreviations: M. T.—Motor Truck; E.—Engine; M. E.—Marine Engine; Ae. — Aeroplane; G. E.—Gas Engine; M. C. —Motorcycle; F. E. — Fire Engine; T. — Tractor.

Names of cars, etc., designed with an asterisk indicates that the factory uses "Red Head" plugs.



Different kinds of plug points or gaps.


COPPER GASKET
USED ON SHOULDER ⅞ AND METRIC BUT NOT ON ½ INCH AS THE THREAD TAPERS

Gaskets for Spark Plugs.

Copper, asbestos lined gaskets are used between bushing and shell on all "separable" plugs, to make it leak proof. They are also used on ⅞ and Metric plugs between shell and where screwed into cylinder—but not on the ½ inch plug, because it has a taper thread and no shoulder on shell. See also pages 607, 717, 288.

CHART NO. 113B—Spark Plug Sizes used on leading Automobiles, Trucks, Motor Boats, M cycles and Stationary and Aeronautic Engines.

Wire Used for Winding a Coil.

Copper wire which is insulated is used for the winding of the primary and secondary winding of a high tension coil or magneto armature.

The primary winding of a coil or (magneto armature) is called primary winding wire. It is usually a single strand of soft copper wire insulated with cotton. This wire is not so long as the secondary winding. The current which passes through this wire is of a low voltage, usually about 6 volts. The quantity or amperes of current is greater than in the secondary winding.

The secondary winding wire of a coil or (magneto armature) is wrapped over the primary winding and it is considerably greater in length. The insulation is silk thread, wrapped around a very fine single strand of flexible copper wire. The pressure or voltage passing through this wire is in the thousands, hence the reason it must be well insulated, but the amperage is practically none at all.

The winding of a Bosch DU4 magneto armature, usually consists of 3 layers of No. 20 or 22 wire, to form the primary winding, and 70 to 72 layers of No. 36 silk covered wire to form the secondary winding.

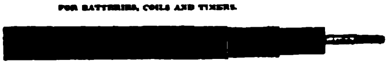
The reader, however, never has occasion to bother with wire on a coil or magneto armature as this is the work of a specialist.

Wire for Ignition Systems.

There are three kinds of ignition wire for general use with the ignition system of a car, as follows:

BRAIDED PRIMARY CABLE

FOR BATTERIES, COILS AND TIMERS.



BRAIDED SECONDARY CABLE

FOR SPARK PLUGS AND MAGNETOS.

BRAIDED DUPLEX CABLE

FOR BATTERIES, TIMERS AND ELECTRIC LIGHTING.

Primary wire or cable, made of several strands of fine wire in order to make it flexible and insulated, oil and moisture proof. This wire is usually used between the battery, coil and timer, for all low tension work, and must be of sufficient size to carry the current, usually No. 14 size is used. (see pages 425 and 427.)

Secondary cable is also made flexible and the insulation on wire is much heavier. This is used to conduct the high tension current from the coil or magueto to the spark plugs. It should be kept free from all metals as much as possible. Size is usually No. 16 or 14.

Duplex cable is also flexible, but generally two to four wires are run in one insulation, of course, being separated from each other by insulations. This wire is generally used for lighting and low tension work.

Metal conduit; a good plan in wiring a car, where several wires are run together, is to enclose the wires in a metal conduit. (see page 426.)

The wires running from coil, or magneto distributor to the spark plug, carry the high tension current and are called secondary cables. This current escapes more readily than from the wires running from the battery to timer or coil. The wires running to the plugs are called "high tension" wires because the tension or voltage is high and current will often jump through the insulation and short circuit (cutting out spark plug) to any metal part it happens to be in contact with. For this reason these wires must be carefully protected and very heavily insulated. (see fig. 12, page 241.)

The primary wires running from the battery to timer or to interrupter on magneto are "low tension." They do not need have as heavy insulation, but the connections should be well made and clean because the pressure is so low the current will not pass over dirty or loose connections, and a loss of current will result. All connections ought to be soldered and taped. (see figs. 6, 7 and 8, page 241.)

The wires running from the battery or timer to the coil connection, are called the primary lead wires, also battery wires. These wires must be of sufficient size to carry the current, as they carry a greater quantity of current than the secondary wires. The secondary wires have much heavier insulation and from outside appearances would seem to be larger, but are comparatively small, as they carry a high voltage but low amperage.

Don't use lamp cord wire under any circumstances as it will give unsatisfactory results and cause missing if damp. (see page 425.)

The size of primary wire generally used is No. 14 or 16 primary cable—the secondary wire is simply called "secondary cable." Both must be waterproof and heat proof—(see pages 425 and 427.)

Wire for the elctric horn is usually No. 18—(see page 425.)

Making Connections.

A grounded connection should be filed or scraped bright before attaching the wire, and the connection when made should be covered with vaseline or paraffine. A copper washer should be placed under the head of the screw, to hold the wire firmly in position—and tightly drawn up.

All connections must be bright and clean, for a dirty connection will add resistance. Binding posts, screws, and the ends of the wire must be scraped clean before the wire is attached—this is very important on low voltage wiring.

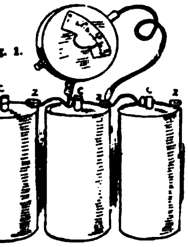
All connections should be made as firm as possible, using pliers to tighten the binding screws. The best connections are made by brass or lead terminals soldered to the ends of the wires. When a connection has been screwed tight, the binding screw and terminal should be covered with vaseline or paraffine, to prevent corrosion, and the whole wrapped with electric tape. This tape comes in rolls, and is sticky, so that it will stay in position when once applied. In addition to being an insulator, it prevents moisture from getting at the terminal.

Short lengths of wire provided with terminals are sold for making dry battery connections, and it is well to use them when dry batteries are used.

No possible cause for leakage of the current should be allowed; a single strand of fine wire projecting from a flexible cable will be enough to cause a short circuit if it should touch metal. (see pages 427 and 432.)

CHART NO. 114—Winding of an Ignition Coil. Ignition Wire—(also see pages 425, 426 and 427), Making Connections.

Fig. 1.



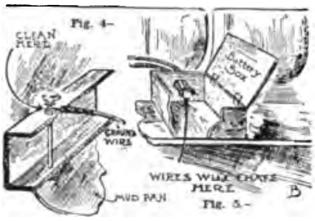


Fig. 6.

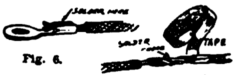


Fig. 7.

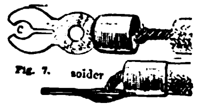


Fig. 9

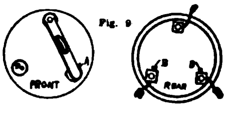


Fig. 10

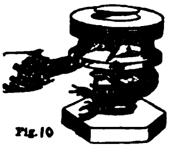


Fig. 2.-

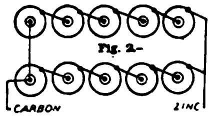


Fig. 8.

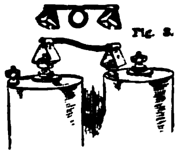


Fig. 12.

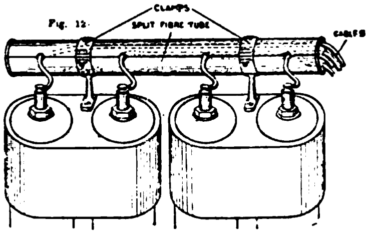


Fig. 13.

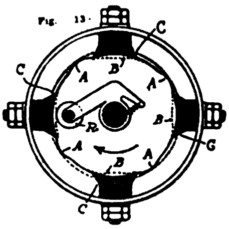
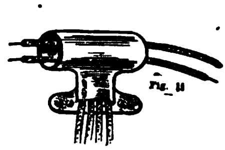


Fig. 11



No. 14.

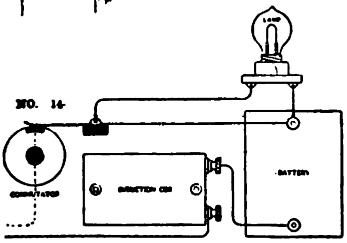


Fig. 15

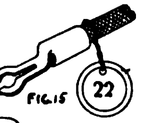


Fig. 16

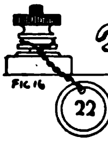


Fig. 1: The missing of ignition may be due to weak batteries. To test, use an amperemeter. Test each cell separately by placing one terminal of meter on terminal of battery and other terminal of meter on other terminal of battery. Each battery ought to show 15 to 25 amperes. If less than 8 amperes, replace. If one should test say 10 amperes and another 20, then the good battery will be brought to the level of the poor battery. Remove it and put in a fresh one. To test a storage battery (see index).

Fig. 2: An emergency dry cell connection. Usually two sets of dry cells are provided when ignition is on dry cells alone. Only one set at a time are used, however. If both sets should run down, a multiple connection of the two sets can be made, as shown above, which will suffice to reach home. Dry cells are now seldom used.

Fig. 3: Quite often missing will occur from loose connections at the battery terminals. See that they are always tight. On some connections, the wire may be broke or not soldered well to the terminal. A good connector called the "Bull Dog" is shown.

Fig. 4: On many cars one wire is grounded—therefore it is essential that the grounded connection is well cleaned and then tightened. A copper terminal should be soldered to the wire—the surface cleaned and drawn tight with a bolt.

Fig. 5: When metal battery boxes are used and dry cells placed in them, dampness will short circuit the batteries through the paper insulation around them. Therefore keep box dry inside, also watch wire where it passes through the metal box.

Figs. 6, 7 and 8 show how to make a connection with wire and terminal; solder and tape all connections.

Figs. 9 and 10: Missing is sometimes caused by loose connections on the switch terminals and battery terminals. See that terminals are clean and tight.

Fig. 11: A good method of protecting primary (battery) wires when they run along the frame.

Fig. 12: Neat method of distributing the secondary or high tension cables on multi-cylinder engines. A divided fibre tube supported on brackets encloses the cables and allows of easy inspection or renewal if required. Any number of leads or cables can be distributed. The eight plug leads required for dual ignition on a four-cylinder engine can be accommodated in a two-inch fibre tube.

Fig. 13: Causes of commutator troubles; (1) worn metal segments (C), often cause missing by not making good contact. (2) The commutator may also become loose on the shaft and get out of time. (3) Spring weak. (4) Loose connections at binding posts. (5) Depressions worn on face of fibre on which the roller (R) travels resulting in the roller jumping (at high speeds) almost over the metal contacts (C). The roller (R) and pin; of the revolving part, will also probably be found in bad shape. To repair; turn down in a lathe or replace with a new one. (6) Grease will coat the insulated fibre ring (O) from one segment to another and cause a short circuit. Too much oil will also cause a glazed surface over the segments (B) and good contact cannot be made between roller (R) and these metal segments.

Fig. 14: How to test for a broken wire: If no external break can be found, yet no spark occurs, then test the wires as follows: Secure a small 6 volt lamp, connect one wire to battery terminal and carry the other wire from lamp to the timer (placing timer segment on contact), if the wiring is perfect the circuit will be completed and light lamp, indicating that the wires are O. K. A small electric bell is also suitable for testing lengths of wire in the same manner.

To test for "grounds" or short circuits, see charts 188-I and 191.

To "test a coil"—see charts 112 and 191 and 192. Also pages 235, 249 and 253.

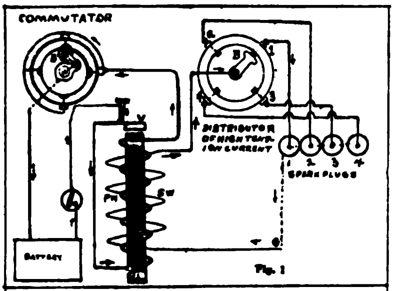
Fig. 15: Mark your wires: Many car owners in looking for trouble in their ignition or lighting systems have disconnected several wires without realizing that they have work before them when it comes to replacing the wires upon their proper connections. This difficulty can be overcome by the use of a box of cheap water colors **with which the insulation can be colored every six inches or so of the length,** or tagged as shown in illustration. This makes tracing of the wires a simple matter.

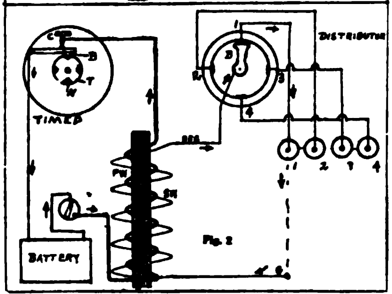
CHART NO. 115—Causes of Ignition Troubles. Testing Dry Cells. Method of Protecting the Secondary Cables.

INSTRUCTION No. 19.

MODERN BATTERY AND COIL IGNITION SYSTEMS; The Timer and Interrupter. Automatic Advance of Spark. Delco, Atwater-Kent, Remy, Connecticut, Bosch, Westinghouse Battery and Coil Ignition Systems. Storage Battery and Direct Current Generators as a Source of Electric Supply. Depolarizing Switch.

†The Modern Battery and Coil Ignition System.





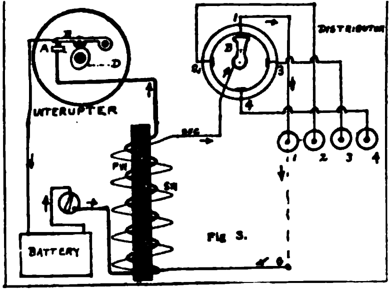


Fig. 1. A distributor and commutator using a "vibrator" type of coil as explained in chart 110, fig. 1A. This system is seldom used. Note the contacts are made by a roller. When contacts are closed, the vibrator on coil operates.

Fig. 2. A similar system but coil is "non-vibrating." When brush or blade (B) is raised by cam (T) contact is made with screw (C) current flows only when contact is thus made.

Fig. 3. This system is similar to fig. 2, except a "cam" of the type used on magnetos is employed, which "interrupts" the flow of current as the nose of cam raises the arm (B), see also fig. 7, page 378.

In order to understand the modern "coil and battery" ignition systems, it was necessary that the reader study the elementary principles of the early forms or methods used for ignition; such as the low tension coil, the high tension coil, the commutator and the timer, also the distributor—all of which have been explained. It ought not therefore be difficult for the reader to grasp the principle and difference of the various makes now to be treated.

The battery and coil system is the modern ignition system, such as the Atwater-Kent, Delco, Remy and others which are supplied with a "constant" source of electric supply when used in connection with a storage battery which is kept charged by the generator.

Constant source of supply means that the ignition apparatus is not dependent upon a mechanical method of generating current, as in a magneto, but the supply of electric current is constantly supplied by a storage battery and the storage battery is constantly supplied with current (direct) by a generator.

The Timer and Distributor.

Are combined in one unit similar to the description of the distributor system shown in fig. 1A, page 230, but the principle is different.

For instance; a commutator of the "roller" or "wiping" contact is employed in fig. 1A, page 230 and fig. 1, this page, which makes a wiping contact, thereby closing the primary circuit on the coil, at which time the vibrator spring (V) fig. 1, (this page), is set in motion, thereby causing the current to be intensified in the secondary winding (SW) of coil. At the same time brush (B) on distributor makes contact with one of the spark plugs in cylinder. By tracing circuit this will be made clear. Note all of the commutator segments are connected together. The spark produced is not a "single" spark, but a "succession" of sparks. This vibration of vibrator (V) is of course, classed as the "electrically" operated vibrator.

This system with a commutator and vibrator coil is seldom used, but instead a system producing a "single" spark, which is made "mechanically" and without the use of a vibrator coil, is the modern method.

---

†This subject is also treated under "Electric Generators"—instructions 27 and 28, see page 377 and 379.

†Open and Closed Circuit Principle.

The modern "interrupter," or "contact breaker," as it is called, is very similar to the interrupter on the magneto and is divided into two types; the **open circuit** and the **closed circuit.** The **open circuit** contact maker is termed a **timer** and closed circuit breaker an **interrupter.**

Open circuit principle; when the arm (B), fig. 2, is raised, contact is **made** with tungsten point screw (C). This closes the primary circuit but it is immediately opened again; termed the **open circuit principle,** because the points of timer are normally **open.** (see also pages 378 and 377.)

Closed circuit principle; the circuit of the primary winding on coil is normally **closed,** because points of timer are **closed** until raised by cam (D). When the "cam" or "interrupter" (D), fig. 3, raises the arm (B), circuit is momentarily **opened** but immediately closed again. This is termed **the closed circuit principle.** This **action** "interrupts" the flow of current suddenly, hence the term "interrupter."

Both of these systems have a "mechanical" method of making and breaking the primary circuit, instead of the "electrical" method, such as the vibrator in fig. 1. Therefore a **coil,** without a vibrator is used and a "single" spark is given at the plug gap,* instead of a succession.

Both systems accomplish the same purpose, which is to interrupt the flow of current in the primary winding in order to cause induced current of a high tension, to flow in the secondary winding as previously explained.

In the open circuit principle the contact must first be made before the current flow can be interrupted. This is made very rapidly; quicker than the eye can detect.

In the closed circuit principle the current is flowing in the primary and is broken or **interrupted by the contact points being separated by the cam;** which runs at cam shaft speed.

***The closed circuit advocates, claim the advantage of perfect synchronism,** due to elimination of "electrical and mechanical lag," whereas the open circuit advocates claim economy.

Electrical lag means that the spark will not occur in the same position as regards piston travel at any and all engine speeds—with a very high speed the piston might have a tendency to travel past the point of ignition, before the open circuit timer **made** and **opened** contact, whereas with the closed circuit principle it merely **opens** the contact.

While all lag factors deal with time in seconds their effect on the engine is the number of degrees they cause the spark to occur off the point it should. Consequently a time factor of only one thousandth of a second means only a variation of 3 degrees at 500 r. p. m. yet means 12 degrees at 2000 r. p. m. and 18 degrees at 3000 r. p. m.

Mechanical lag is eliminated much for the same reason and the **quicker and simpler the mechanism to "interrupt"** the flow in the primary the quicker the spark.

For this reason some of the systems have been additionally improved by adding an automatic advance of the spark, by a governor arrangement placed in the timer housing, so that the timer shaft will advance with the speed of the engine and cause the spark to occur as near the proper time as possible (see page 248).

Referring to fig. 3, we have then a simplified explanation of the closed circuit principle—note the interrupter (D). At a glance it appears to resemble a magneto interrupter or contact breaker arrangement—and it is very similar, although a magneto with its "alternating" current is not used to supply the electric current, but **instead,** a "direct" current is used from the battery or generator. Yet the same principle; **interruption** of the current **flowing** through the primary winding of the coil is exactly the same.

For instance, the flow of current through the primary winding of the coil is suddenly "interrupted" by the cam raising the interrupter arm (B) from contact (A); the current is diverted to the condenser (not shown here, but a part of all coils, see fig. 5, page 228), which is charged to a fairly high voltage and which then discharges through the inductance of the primary winding of the coil; causing a rapid demagnetization of the iron core of the coil that "induces" the high tension current in the secondary winding. This high tension current is then carried from the "distributor" to the spark plugs.

The system in fig. 3, has been improved by having a cam (D) with the same number of projections as there are cylinders, thereby rendering it possible to operate the "distributor and timer or interrupter," at the same speed—see pages 378 and 377.

The open circuit principle is carried out in fig. 2, and is very much the same, although the circuit is **open** at all times except when arm (B) is in contact with (T); the spark really occurs just at the instant that timer contacts are **opened,** that **is,** the contact is **"made"** and **"opened" suddenly,** meaning practically the same principle as in fig. 3, where the circuit is **closed** until opened by interrupter. There **are as** many notches (N) in cam (T) as there are cylinders.

Therefore summing up the three distributor systems of the battery and coil system of ignition, we find that the old style "commutator" system, fig. 1, has been discarded and the two systems in general use are as per figs. 2 and 3.

The disadvantage of the "commutator" system, fig. 1, is due to the use of a "vibrator" coil. See instruction 20.

Another point to bear in mind is that both the open and closed circuit systems give a "single" spark, whereas the commutator type gives a "succession" of sparks. (see page 250.)

Another point to remember is that a coil without a vibrator is used on both the "open" and "closed" circuit battery and coil system of ignition—for previously stated a vibrator is not necessary with a single spark timer.

---

*Also claim that it allows the **maximum amount of contact** which permits complete saturation of coil at high engine speeds—and no doubt is a reasonable claim.

†Page 248 shows a typical open circuit type. Page 254 a popular closed circuit type system. See also pages 378 and 377.

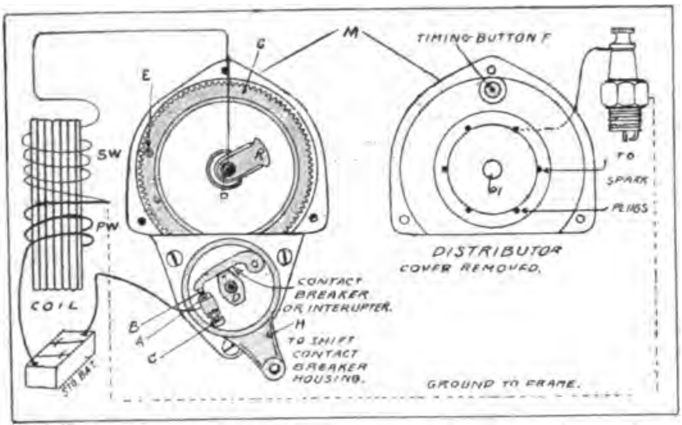

M
C
E
TIMING BUTTON F
SW
PW
R
D
COIL
STO. BAT.
B
A
C
CONTACT BREAKER OR INTERUPTER.
H
TO SHIFT CONTACT BREAKER HOUSING.
DISTRIBUTOR COVER REMOVED.
TO SPARK PLUGS
GROUND TO FRAME.

Fig. 4 The true magneto type interrupter and distributor for a six cylinder engine as used with a "coil and battery" system. Note the "interrupter" and "distributor" operate at different speeds. The interrupter cam is revolved from cam shaft but turns 1½ turns to one of crank shaft. The distributor brush (R) makes one revolution to two of the crank shaft. This is due to using a two point cam (D).

Magneto Type "Interrupter."

A first glance at the interrupter and distributor, in fig. 4, the reader would think this a "magneto" system and that is the reason for illustrating it. To show the reader the simplicity, and to bring out the difference between the "timer" fig. 2, and "interrupter" system, fig. 3, page 242.

The contact breaker or interrupter and distributor in fig. 4 are of the magneto type and the principle is practically the same as a magneto, but the "source" of electric supply is not "alternating" current taken from a magneto, but is "direct" current, taken from a storage battery or "direct" current generator if engine is running fast enough for the generator to overcome the battery voltage and recharge the battery as explained on page 337.

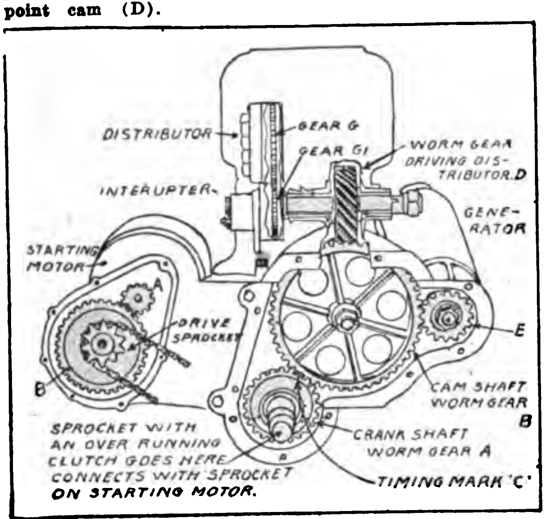


Fig. 5. Note the gear G, is driven by gear G1 which in turn is driven by a spiral worm gear from the cam gear. This system was used on the Studebaker six. See above, for relative speed of interrupter cam (D) and distributor brush (R). (Studebaker generator is now driven in a vertical position and ignition is as per pages 368, 350, 372.

Here we have practically the same principle as explained in fig. 2, page 242, except that the circuit is closed until "interrupted" by movement of cam. Whereas in fig. 2, the circuit is open until contact points are closed by movement of timer.

If we applied this system, fig. 4, this page, to a four cylinder engine, it would be neccessary to revolve the cam (D) twice, during two revolutions of the crank shaft, or the same speed as crank shaft, therefore the distributor would revolve but once, during two revolutions of the crank shaft. Therefore the distributer would be geared to run half the speed of cam.

We could use a cam with four lobes instead of two, and run it at one half the speed of the crank shaft, causing it to revolve once to two revolutions of the crank shaft; then the distributor and timer would revolve at the same speed, or ½ the speed of the crank shaft.

Six cylinder engine: Because there are but two lobes or projections on the cam (D). in fig. 4, and because it opens the circuit twice during one revolution of the cam, we would obtain two sparks during one revolution. If a six cylinder engine, we would need 3 sparks to one revolution of crank shaft, or six sparks to two revolutions, therefore the cam (D) must turn 1½ times to one turn of crank shaft.

The distributor, however, would turn but 1 time to two revolutions of crank shaft, therefore it would have to be geared to run ½ the speed of the crank shaft, or 1 turn to two of the crank, because the brush (R) must make 6 contacts during its one revolution.

A simpler plan, would be, to use a cam with 6 projections or lobes, instead of two projections, as shown in fig. 2, page 245. This cam, with 6 projections would then run at the same speed, as distributor, or one revolution to two of the crank shaft. The Studebaker and Reo, use a system of this principle, which is the Remy system.

The coil is a single "non-vibrating" type mounted above the starting motor and to the side of the distributor and interrupter. The primary current is taken from the battery or generator, through interrupter, thence primary winding of coil. It is there transformed into a high pressure and carried from secondary winding to the distributor arm (R) and distributed to the spark plugs.

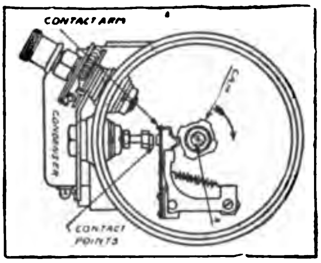


Fig. 6. The Delco timer: The contact points are open, therefore circuit is open, until closed by cam. However, the "single" spark occurs at the instant the timer contacts are opened after making contact. Both principles are similar. (see page 378.)

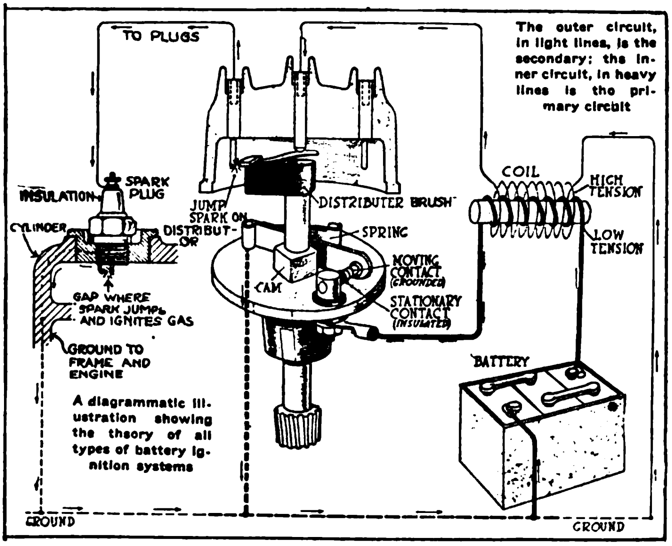
On a four cylinder engine this cam would turn at cam shaft speed. If there were but 2 lobes on cam, it would turn at crank shaft speed.

CHART NO. 116—The "Magneto type" Interrupter as applied to the Modern Battery and Coil System of Ignition. (See page 368—later Studebaker system.)

Parts of a Modern Battery and Coil System of Ignition.

The parts of this system consist of distributor, timer, ignition coil, spark plugs and storage battery—see page 254 for Connecticut, page 248 Atwater-Kent, Delco 127 and 377.

The distributor is usually placed over the timer. First note the timer shaft which is driven from the cam shaft, usually by a spiral tooth gear and at cam shaft speed.


TO PLUGS
SPARK PLUG
INSULATION
CYLINDER
JUMP SPARK ON DISTRIBUT-OR
DISTRIBUTER BRUSH
SPRING
MOVING CONTACT (GROUNDED)
STATIONARY CONTACT (INSULATED)
CAM
COIL
HIGH TENSION
LOW TENSION
BATTERY
GAP WHERE SPARK JUMPS AND IGNITES GAS
GROUND TO FRAME AND ENGINE
GROUND
GROUND

The outer circuit, in light lines, is the secondary; the inner circuit, in heavy lines is the primary circuit

A diagrammatic illustration showing the theory of all types of battery ignition systems

Fig. 5.—Diagram illustrating principle upon which the battery and coil ignition system operates. (Motor Age.)

††The distributor brush is connected to upper end of this shaft and as it revolves, makes contact with the spark plug terminals. Note center contact on rear of brush, connecting with secondary of coil.

Timer.

The timer is that part, containing the interrupter or contact breaker mechanism and is placed below the distributor. This mechanism simply makes and then breaks the flow of current in the primary circuit if open circuit type, and opens the circuit if closed circuit type.

The Coil.

Is the same principle of high tension coil as described on page 220, but without a vibrator. The condenser can be built in or on the coil but is now often placed on the timer (see page 252). The coil can be mounted on the dash, separate from the distributor and timer or adjacent to it.

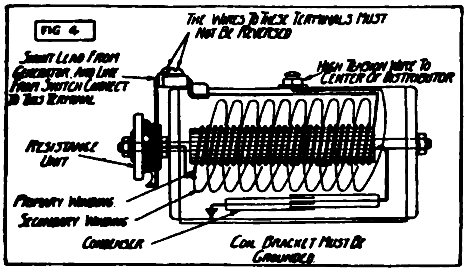


FIG 4
THE WIRES TO THESE TERMINALS MUST NOT BE REVERSED
SHUNT LEAD FROM GENERATOR AND LINE FROM SWITCH CONNECT TO THIS TERMINAL
HIGH TENSION WIRE TO CENTER OF DISTRIBUTOR
RESISTANCE UNIT
PRIMARY WINDING
SECONDARY WINDING
CONDENSER
COIL BRACKET MUST BE GROUNDED

Fig. 4. Delco coil; showing winding connections, condenser and resistance unit This coil is similar to any other high tension coil, without vibrator.

The Condenser.

For description of condenser and its purpose see pages 228 and 378.

†To test condenser: remove the distributor head and have some one crank engine. Notice if there is excessive sparking at the timer contact points, if so, then condenser is defective. A slight spark, however, will sometimes be observed with a good condenser.

Testing coil: The mechanic should familiarise himself with the spark obtained by removing the wire from one of the plugs and letting the spark jump to the engine (not to the spark plug). A good coil will produce a spark with a maximum jump of at least ¼ inch, provided other conditions are normal. See pages 236, 253, 418 and 378.

**Timer Contacts.

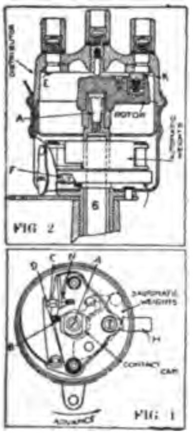
The timer contacts are called "interrupters" or "contact breakers" and are shown on pages 252 and 378.

The timer contacts shown at D and C (fig. 1), are two of the most important points. They are **tungsten** metal, which is extremely hard and requires a very high temperature to melt. Under normal conditions they wear or burn very slightly and will very seldom require attention but in the event of abnormal voltage, such as would be obtained by **running with the battery removed** (on generator alone); or with the ignition *resistance unit shorted out, or with a defective †condenser, these contacts burn very rapidly and in a short time will cause missing.

These contacts should be so adjusted that when the fibre block B is on top of one of the lobes of the cam the contacts are opened the thickness of the gauge on the distributor wrench (usually furnished by the manufacturer.)—see page 378.

Adjust contacts by turning contact screw C and lock with nut N. The contacts should be dressed with fine emery cloth so that they meet squarely across the entire face—see pages 377 and 378.

Referring to illustration fig. 2;—shaft which drives distributor rotor and timer. High tension current passes from distributor brush (K) to spark plug terminals. A—is screw for setting position of timer cam. Note automatic weights or governor which automatically advances the spark. Fig. 5 is not automatic. See page 377.



Figs. 1 & 2.—Sectional view of Delco distributor and top view of timer. Timer is mounted under distributor. (see pages 377, 378 and 132.)

****To set the timer, see pages 250 to 253, 316, 317, 390, 377, 378. *See foot note bottom page 246, and page 378. †A defective condenser such as will cause contact trouble will cause serious missing of the ignition. See also page 308, testing a magneto condenser.**

††The "gap-type" distributor is one used in fig. 5, because contact is not actually made, but jumps to spark plug terminals. (see also page 247.) A brush type distributor is as per "Bosch," page 252.

†To set the timer (Delco system on Buick as an example): (1) Fully retard spark lever on steering wheel; (2) Turn engine crank until 7° mark on fly wheel is in line with center mark, which is approximately 1" from dead center mark on the fly wheel with No. 1 piston on the firing stroke. (3) Loosen screw in center of timing mechanism and locate the proper lobe of the cam. Turn until the rotor brush comes under the position which No. 1 high tension terminal on the distributor head occupies when the head is properly located. (4) Set this lobe of the cam so that when the back lash of the distributor gears is rocked forward the contacts will be open and when the back lash is rocked backward the contacts will just close. Tighten the screw and replace rotor and head. The shaft runs clockwise when viewed from the top, and the spark occurs when the contacts open. Firing order of "six" is 1, 4, 2, 6, 3, 5; of the "four," 1, 3, 4, 2.

The Electric Current.

For Delco, or in fact all of the ignition systems treated in this instruction, is taken from a storage battery to start on and to run on, under a speed of approximately 10 miles per hour. Over this speed the current is taken from the generator which will be explained further on, under the heading "Generators."

**Resistance Units.

Purpose: With the **closed circuit type of** ignition some method must be employed to disconnect the primary circuit, if the switch is left "on" accidentally when engine is not running. Resistance units and Thermostats are therefore employed.

The resistance unit used with the Delco system is for the purpose of obtaining a more uniform current. (see page 378.)

It consists of a coil of resistance wire wound on a porcelain spool as shown in fig. 4, page 245. Under ordinary conditions it remains cool and offers little resistance to the passage of current. If for any reason the ignition circuit remains closed for any considerable length of time, the current passing through the coil heats the resistance wire, increasing its resistance to a point where very little current passes and insuring against a waste of current from the battery and damage to the ignition coil and timer contacts. This unit also insures uniform current through the primary winding.

Electric Thermostat.

A thermostatic circuit breaking mechanism is used on the Connecticut closed circuit system, as explained on page 254. It is used to open the circuit in case the ignition switch is left "on."

The Depolarizer Switch.

Also called a pole-changing switch—used in connection with ignition systems is provided for the purpose of keeping the contact points on timer clean. See page 248.

*Automatic and Hand Advance of Spark.

The advantage of the automatic spark advance as explained on page 249 is this: With the spark lever set at the running position on the steering wheel, the "automatic" feature gives the proper spark for all speeds excepting a wide open throttle at low speeds, at which time the spark lever should be slightly retarded. When the ignition is too far advanced it causes loss of power and a knocking sound within the engine. With too late a spark there is a loss of power (which is usually not noticed excepting by an experienced driver or one very familiar with the car), and heating of the engine and excessive consumption of fuel is the result. (see page 377.)

The reason for using the manual (hand) control of spark is as follows: a heavy charge burns quicker than a light one. For this reason the engine will stand more advance with a half open throttle than with a wide open throttle. The hand control is therefore, installed in order to secure the proper timing of the ignition due to these variations and to retard the spark for "starting," "idling" and "carburetor adjusting."

Driving the Timer and Distributor.

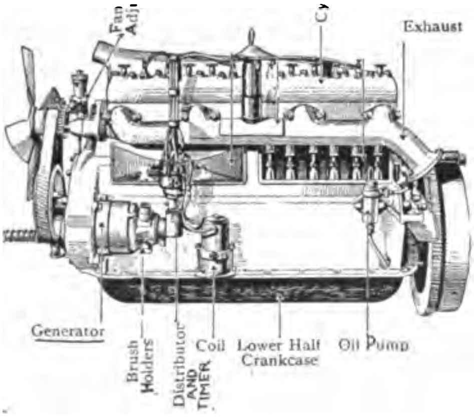


Fig. 8. Modern method of driving the timer and distributor through the generator shaft.

The modern method of driving the timer and distributor, is from the generator shaft as shown in illustration, fig. 8.

The generator shaft is driven, usually by a silent chain, encased. The timer shaft is driven from generator shaft by a spiral gear and geared so it will run distributor and timer at one half the speed of crank shaft.

Quite often the timer and distributor shaft is operated from the cam shaft—in fact there are various methods employed, but in most every instance it runs at cam shaft speed (½ the speed of crank shaft), made possible by placing lobes on cam, to give the desired number of sparks (see fig. 6, page 244, and pages 377 and 378.)

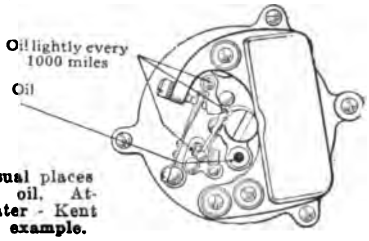
**It is a very easy matter to check the resistance unit (explained further on), by observing its heating when the ignition button is out and the contacts in the distributor are closed. If it is shorted out it will not heat up, and will cause missing at low speeds. See page 378.

†See pages 390, 250 to 253, 316, 317, and 182 for Delco.

*The richness of the mixture and the amount of compression are also factors in the time required for combustion to be complete—see pages 377 and 307.

The timer and distributor shaft runs in one given direction—clockwise or counter-clockwise.

The usual adjustments are to dress the contact points on timer with a fine file when they are badly pitted so that the maximum opening is given. Spark plug gaps must also be adjusted correctly. See chart 228, also page 250.



Usual places to oil. Atwater - Kent as example.

The Atwater-Kent Open Circuit Ignition System.

As an example of a modern battery and coil system of ignition, we will use the Atwater-Kent Type K-3 system. (This concern also manufactures a closed circuit system, called the model "CC" as illustrated in chart 118).

Parts: Consist of: (1) the distributor and timer, which is called the unisparker; (2) the coil, which consists of a simple primary and secondary winding, sealed in an insulated cylinder. The coil has no vibrators, contacts, or other moving parts; (3) the depolarizer switch; (4) the automatic spark advance.

Description: The timer and distributor are mounted in one housing; as shown in fig. 2, chart 117.

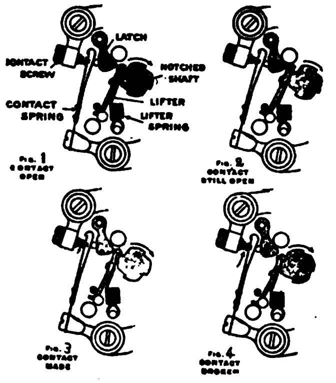


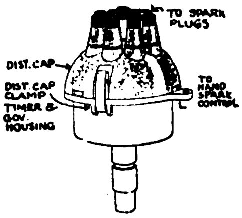
FIG. 1 CONTACT OPEN
FIG. 2 CONTACT STILL OPEN
FIG. 3 CONTACT MADE
FIG. 4 CONTACT BROKEN

Figures 1, 2, 3 and 4 show the operation of the Atwater-Kent open circuit contact maker clearly. It will be noted that in fig. 1 the lifter is being pulled forward by the notched shaft. When pulled forward as far as the shaft will carry it (fig. 2), the lifter is suddenly pulled back by the recoil of the lifter spring. In returning, it strikes against the latch, throwing this against the contact spring and closing the contact for a very brief instant—far too quickly for the eye to follow the movement (fig. 3).**

Fig. 4. Shows the lifter ready to be pulled forward by the next notch.

Note that the circuit is closed only during the instant of the spark. No matter how slow or how fast the shaft is turning, the lifter spring will always pull the lifter back at exactly the same speed, so that the operation of the contact, and therefore the spark, will always be the same, no matter how slow or how fast engine runs.

The timer shaft is a ½ inch shaft, driven usually from the cam shaft and at cam shaft speed. It is also quite often mounted on the generator and driven from it, as shown in fig. 8, page 246. It should always be installed in the coolest location available.



The function of the Atwater-Kent system is to produce a single hot spark for each power-impulse of the engine, accurately timed to occur at the right instant to produce the greatest possible power and efficiency.

The contact points in the timer do not touch except during the brief instant of the spark. The ignition circuit is therefore normally open and no current flows, even though the ignition switch be left "closed." This dispenses with the use of a resistance unit, or thermostat as described on page 246.

The operation of the contact maker: This consists of a pair of contact points, normally open, which are connected in series with a battery and the primary circuit of a simple non-vibrating induction coil.

A hardened steel latch, against which the trigger strikes on its recoil and which in turn operates the contact points, completes the device, see figures 1, 2, 3 and 4.

The distributor forms the upper part of the Unisparker, the high tension current from the coil is conveyed by the rotating distributor block arm (DA), fig. 2, chart 117, thence to the spark plugs in their proper order of firing.

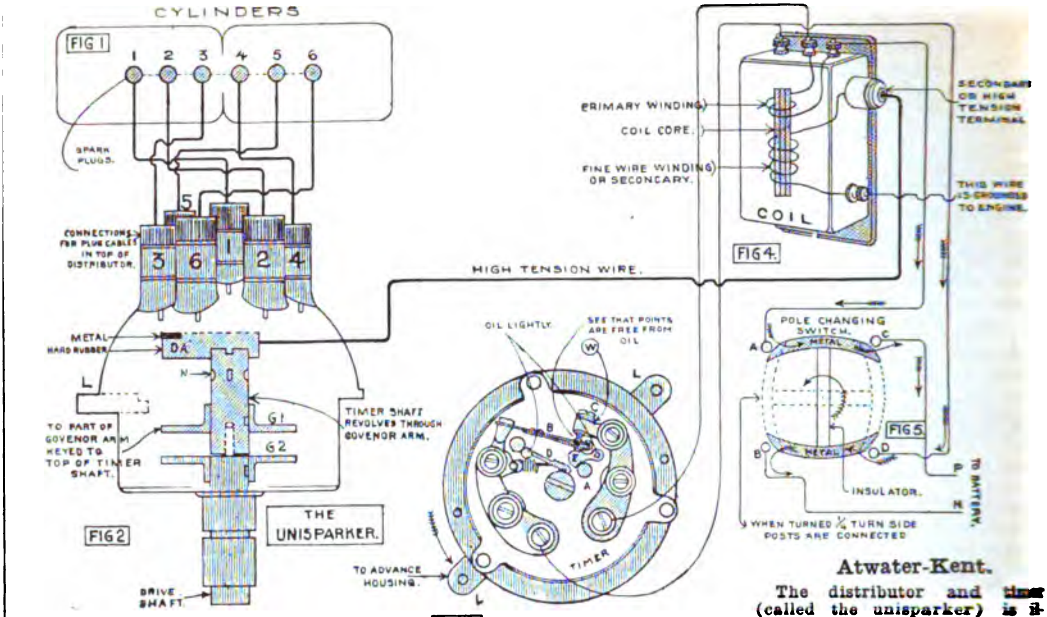
Gap type distributor; the distributor arm (DA) does not touch contacts above it, but passes close to them (gap $\frac{1}{60}$th in.) as it revolves and the high tension current jumps the slight gap, therefore termed a "gap-type" distributor.

The direction of rotation is usually clockwise, when looking down upon the device.

---

*Do not think that these parts do not work properly because you cannot see their movement. The contact maker of the Unisparker may be likened to a watch, which, because of the small size and extreme accuracy and hardness of its moving parts, is subject to very little wear. Don't change tension of spring or alter parts.

****There are as many notches (fig. 1) in the timer shaft,** as there are cylinders, and as many leads from the distributor to spark plugs, as there are cylinders.


CYLINDERS
FIG 1
1 2 3 4 5 6
SPARK PLUGS.
CONNECTIONS FOR PLUG CABLES IN TOP OF DISTRIBUTOR.
3 6 1 2 4 5
METAL
HARD RUBBER
DA
N
L
G1
G2
TO PART OF GOVENOR ARM KEYED TO TOP OF TIMER SHAFT.
TIMER SHAFT REVOLVES THROUGH GOVENOR ARM.
THE UNISPARKER.
FIG 2
DRIVE SHAFT
HIGH TENSION WIRE.
OIL LIGHTLY
SEE THAT POINTS ARE FREE FROM OIL
W
L
B
C
D
E
A
TIMER
TO ADVANCE HOUSING.
FIG 3.
PRIMARY WINDING
COIL CORE.
FINE WIRE WINDING OR SECONDARY.
COIL
FIG 4.
SECONDARY OR HIGH TENSION TERMINAL
THIS WIRE IS GROUNDED TO ENGINE.
POLE CHANGING SWITCH.
METAL
A
C
B
D
FIG 5.
INSULATOR.
P
N
TO BATTERY.
WHEN TURNED ¼ TURN SIDE POSTS ARE CONNECTED

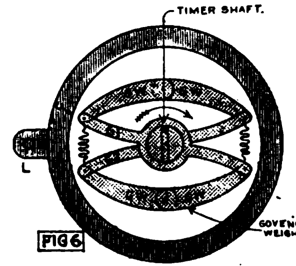


FIG 6

GOVENOR WHEN RUNNING SLOW.

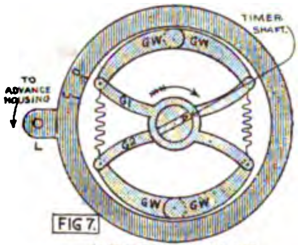


FIG 7.

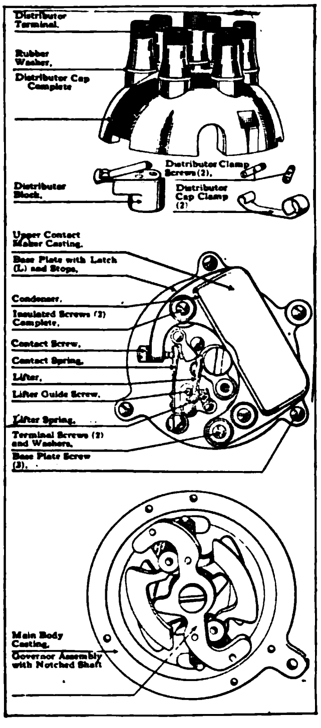
GOVENOR WHEN RUNNING FAST.

Atwater-Kent.

The distributor and timer (called the unisparker) is illustrated in fig. 2, it consists of a timer with its contact breaker or "maker," which would be more appropriate, mounted on the timer shaft, but independent of each other.

The timer is illustrated in fig. 3, and explained on page 247.

The governor, figs. 6 and 7, is mounted directly under the timer. One arm of the governor (G1), is attached to the upper part of the timer shaft which is free to advance with the action of the governor. The other arm of governor automatically advances the time of spark as the speed of engine increases, by centrifugal action of governor weights (GW), as shown. Note position of end of timer shaft (A), at retard, fig. 6, and advance, fig. 7. Note at "retard" governor arm (G1) is at (C), whereas at full speed it has advanced to (D). (Marks shown on left hand side of housing.)


Distributor Terminal.
Rubber Washer.
Distributor Cap Complete
Distributor Clamp Screws (2).
Distributor Block.
Distributor Cap Clamp (2)
Upper Contact Maker Casting.
Base Plate with Latch (L) and Stops.
Condenser.
Insulated Screws (2) Complete.
Contact Screw.
Contact Spring.
Lifter.
Lifter Guide Screw.
Lifter Spring.
Terminal Screws (2) and Washers.
Base Plate Screw (3).
Main Body Casting.
Governor Assembly with Notched Shaft

The distributor, which distributes the current to the spark plugs (six in this instance), in their respective firing order of 1, 4, 2, 6, 3, 5, is mounted on the upper end of the shaft. The distributor arm (DA), revolves with timer shaft and passes the high tension current to the terminals of the distributor, as six sparks are required per revolution, there are six notches on timer cam, and the distributor points are spaced 60° apart.

The coil, is a double wound coil with a secondary and a primary winding. The primary current (6 volts), coming from the battery or generator is carried through a pole changing switch through timer contacts, where the current is opened and closed at the proper time by the contact arm (D) (fig. 3), coming in contact with notches (N, fig. 2), which raises latch (E), causing contacts (B and C), which are insulated from each other, to come in contact: thereby closing the primary circuit in the coil. This causes a secondary current to be set up in the secondary winding of high voltage. This secondary current is then distributed to the spark plugs by the distributor. (Cylindrical type coil now used—see page 249.)

There are as many notches (N), in the timer shaft as there are cylinders and as many distributor leads to spark plugs as there are cylinders.

Polarity Switch.

The polarity switch, is intended to prevent the points on (B and C) from becoming worn and pitted. "Direct" current is used which has a tendency to burn and pit the points, whereas an alternating current is much easier on the points. Therefore to alternate the flow of current from N to S and S to N or positive to negative and negative to positive—is the principle of this style switch.

As stated above, "direct" current is used with all battery systems, therefore a steady flow in one direction has a tendency to deposit the metal from one point to the other—but by changing this flow of current occasionally, the deposit will be put back to the other point again. This is similar to electro-plating.

Note the action of the polarity switch: D is now flowing negative, A is flowing positive. By turning switch one quarter turn, the poles are changed; A will become negative and D will become positive. This change is made occasionally when running and has a tendency to keep contact points clean.

CHART NO. 117—The Atwater-Kent High Tension Coil and Battery Open Circuit Ignition System with Automatic Advance Timer and Distributor. Upper illustrations are slightly exaggerated.

*The later Atwater-Kent system is a closed circuit principle, see fig. 1, page 249 and page 252.

*The Automatic Advance of Spark.

Governor: The Delco and Atwater-Kent systems employ a mechanical governor for advancing the spark when the engine is speeded. A governor of the centrifugal type is employed on both systems, but of slightly different construction. The purpose of the governor is to cause the timer notched shaft to turn in the direction of rotation, causing the contact to make and break earlier as the speed increases.

For instance; refer to fig. 6, chart 117. Assume engine is running slow and governor is in retarded position. Note position of notch (A) in top of timer shaft. If engine is speeded up, the governor weights (GW) fly outward, causing timer shaft to turn further advance in direction of rotation—it is clear to see that the contact would be made sooner at D and E (fig. 3). The top of timer shaft is driven through the governor arm—see fig. 2.

In addition to the governor advance—the distributor housing can also be advanced by hand, the two working independent of each other (see fig. 3), L is connected with spark lever on the steering wheel.

The manual or hand control is for the purpose of securing the proper ignition control for carburetor adjusting, slow idling, retard for starting and variable conditions which cannot be held constant.

The automatic spark control is for the purpose of securing the proper control due to variations in speed alone, and all that is required for normal driving is to secure the proper spark control for slow driving from 10 to 15 miles per hour (set the spark lever about 2/3 advanced) and the automatic feature will give the proper spark position for all higher speeds and for all lower speeds, excepting when the throttle is wide open, at which time the spark lever should be slightly retarded.

Where the hand spark control lever is used, it should be so proportioned as to give not more than ¼ to ½ inch of movement, for the entire range of the spark lever on the steering wheel sector.

Range of spark advance: The high tension distributor is carried on a central shaft, which connects below the governor, so that the distributor block is not moved by the automatic advance mechanism. This permits of a wide **range of spark advance** without affecting the synchronism. The maximum advance is about 45 degrees, of crank shaft travel; at 2400 r. p. m.

The source of electric supply for this system, also all other systems of this kind, is from the storage battery. The storage battery, as previously explained is charged from an electric generator run from the engine.

The current consumption is very small, but the strength or pressure of current as required by the coil is necessary for a single spark system. Therefore keep the battery fully charged at all times.

In case of an emergency, dry cells can be used connected six in series. If dry cells are used, they should be insulated from each other by wood or fibre battens for if damp they will give but little service.

The Wiring.

The wiring of the Atwater-Kent open circuit system is explained on page 248. In the illustration on page 248 a two wire system is used, but a single or grounded return could be used as on the A.-K. **closed** circuit system—model "CC," page 252, and fig. 1, below.

The high tension wires from distributor to plugs should be 5/16 in. di., including insulation.

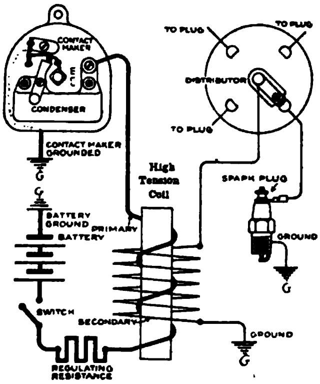


Fig. 1. Single wire, grounded return of A.-K. model "CC" closed circuit system—see also page 252.

Testing.

If engine misses without regard to speed, test each cylinder separately by short-circuiting the plug with a screw driver, allowing a spark to jump. If all cylinders produce a good, regular spark, the trouble is not with the ignition system.

If any one cylinder sparks regularly, this will indicate that the system is in working order so far as the Unisparker and coil are concerned, and the trouble is probably in the high-tension wiring between the distributor and plugs or in the plugs themselves. Examine carefully the plugs and wiring. Leaky secondary wiring is frequently the cause of missing and back-firing.

Frequently, when high-tension wires are run from the distributor to the spark plugs through metal or fibre tubing, trouble is experienced with missing and back-firing, which is due to induction between the various wires in the tube. This trouble is especially likely to happen if the main secondary wire from the coil to the center of the distributor runs through this tube with the spark plug wires.

Wherever possible, the distributor wires should be separated by at least ½ inch of space and should be supported by brackets or insulators rather than run through a tube. In no case should the main distributor wire be run through a conduit with the other wires.

If irregular sparking is noted at all plugs, examine first the battery and connections therefrom. If the trouble commences suddenly, it is probably due to a loose connection in the wiring. If gradually, the batteries may be weakening or the contact points may require attention. See that contacts are clean and bright, and also that the moving parts are not gummed with oil or rusted.

---

*The advance and retard of spark is explained under Ignition Timing—pages 305 and 307.

*The Atwater-Kent Closed Circuit Ignition System.

This system is termed the type "CC." It is illustrated in chart 118. The timer contact breaker or interrupter is shown in the illustration to good advantage. **There is but one adjustment**, which is the space at points, and which is altered by screw (S) and moving arm (B).

The condenser is small and mounted directly on timer. **The coil** used on both systems is now cylindrical instead of box type and can be placed along side of the timer and distributor or separate.

A resistance unit for protecting at low speeds or if switch is left on, as explained under the thermostat principle, page 246, is carried in the coil with the CC type. In fact all **closed circuit** systems must be provided with some form of circuit opener in case switch is left on. (see fig. 1, page 249 showing circuit of "regulating resistance.")

Single vs. Succession of Sparks.

An ordinary vibrator coil makes several sparks, usually starting before piston is on top of compression, and ending considerably after top of compression. The hottest spark ignites the gas. The spark should occur before top of compression and ignite the gas before top is reached so that combustion will have time to take place on the top, at the point of highest compression, thereby getting greatest power from engine and not after the top, when compression is being lowered. (see Ignition Timing.)

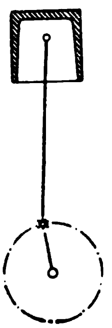


Fig. 8.

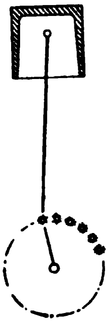


Fig. 9.

Fig. 8 represents the Remy, Delco, Westinghouse and Atwater-Kent "single spark"—a hot one at the right time, which causes the gas to ignite quick without lag and consumes very little current.

Fig. 9. Note the succession of sparks. This represents the sparks as they occur on the old style vibrator coil—several after top of stroke. The hottest one ignites the gas, but usually late.

The Atwater-Kent and other systems of the kind are intended to make a single, quick, hot spark, igniting the gas before the top of compression stroke, giving the gas time to combust by the time the piston is on top of the compression stroke. Hence, greater power and economy in current.

Timing
Atwater-Kent System—when hand spark control lever is not used.

(1) place piston of No. 1 cylinder on top dead center between compression and power stroke (see index, "finding compression stroke"); (2) slowly and carefully turn the unisparker backwards or counter clockwise (contrary to direction of rotation of the timer shaft), until a **click** is heard. This click happens at the exact instant of the spark; (3) at this point it should be set by tightening the set screws on the timer shaft, being careful not to change its position; (4) now remove the distributor cap, which fits only in one position, and note the position of the distributor block on the end of the shaft. The terminal to which it points is connected to No. 1 cylinder. The other cylinders in their proper order of firing are connected to the other terminals in turn, keeping in mind the direction of rotation of the timer shaft.

When timed in this manner the spark occurs exactly on **top dead center** when the engine is turned over slowly.

At cranking speeds the governor automatically retards the spark for safe starting, and as the speed increases, the spark is automatically advanced, thus requiring no attention on the part of the driver.

Timing
Atwater-Kent—When a hand spark control lever is used.

This setting is the same as given above, except—the position of the spark advance lever on steering wheel sector, should be within ⅛ inch of full retard and connecting levers should be such as to give the unisparker an allowance of ⅜ to ½ inch of movement for the full range of spark advance.

After the spark lever is connected up and the unisparker is in position, it should be left loose at the driving gear or at some other convenient point, and, with the engine on dead center as above directed, the shaft of the unisparker should then be turned forward or in the same direction as that in which it normally rotates, until a **click is heard**, at which point it should be set by tightening the driving connection.

The secondary wires are then connected to the right plugs as previously explained.

Adjustments of Atwater-Kent.

Do not adjust or disturb the contact points until you are convinced that they need the attention.

The normal **gap** between the contact points, is from .010 in. to .012 in. never closer.

When contact points are working properly, small particles of tungsten will be carried from one point to the other, sometimes forming a roughness and a dark gray color on their surfaces. This roughness does not in any way affect the proper working of the points, owing to the fact that the rough surfaces fit into each other perfectly.

However, when it becomes necessary to take up the distance between these points due to natural wear, it is advisable to remove both contact screw and contact spring, and with a new fine file dress down the high spots. Shim washers (W—fig. 8, chart 117) can also be removed from under the contact screw head until the gap between the points is correct. This makes it possible to obtain a more accurate adjustment and eliminates any danger of high points on either contact touching each other when system is at rest. **Bear in mind that these contacts** (as well as all tungsten contact points) **are very** hard to file and that it is necessary to remove only a very small amount of metal.

Spark plug gaps—when used with A. K. system should be adjusted to approximately .025. **Too wide a gap** will cause misfiring, **especially** at low speeds and hard pulls. **If too close**, engine will operate unevenly at ilding and miss at high speeds. (see also page 233.)

---

*Some of the cars using Atwater-Kent system are given in the "Specifications of Leading Cars"—charts 229-234.

**The Remy Ignition System.

The Remy ignition system consists of the combined timer-distributor unit, a coil and the switch (see chart 118). The system operates on the **closed-circuit** principle, and is distinguished by the fact that it has but two moving parts—the cam and the breaker arm. The system is made for four-, six- and eight-cylinder engines.

In operation, the rotation of the cam C brings its corners in contact with a fibre plug which is riveted to the breaker arm. The arm thus is lifted, separating the contacts. Inasmuch as the moving parts are very light and a considerable period is allowed for the saturation of the primary winding in the coil, both mechanical and electrical lag are practically eliminated.

Only **hand advance** of the breaker mechanism is provided.

Whole mechanism stationary: Another feature of the Remy unit is that the whole mechanism is stationary. Advancing or retarding the spark does not move any of the wiring. This is accomplished by mounting the breaker mechanism on a plate. The plate is attached to the advance lever and is moved with it, thus rotating the breaker mechanism partly around the cam.

The distributor mechanism consists of the usual Bakelite cover, with the terminals molded in place. There is no wiping contact, the spark jumps from the radial distributor arm to the terminals. Wear, therefore, is eliminated.

On top of the coil there is a miniature resistance coil in series with the primary winding. This is to protect this winding in the event the engine should remain idle for any length of time with the switch closed. In short, it protects the winding and also prevents excessive drain on the battery.

Remy adjustments: Under ordinary conditions the contact points, which are iridium-platinum or tungsten should not require attention more than twice a season.

They should be dressed with a fine flat file to present perfectly smooth surfaces.

The contacts should be adjusted with the wrench provided so that the maximum opening is .020 to .025 in. The rebound spring should be at least .020 in. from the breaker arm, when the contacts are at maximum opening.

For best results the **spark-plug gaps** should be .025 to .030 in.

If the **engine misses when idling or at light loads**; the gaps at the plugs should be wider. If the engine misses at high speed or when pulling hard the gaps should be narrower.

The oiler on the shaft should be kept filled with medium cup grease and screwed down two or three turns occasionally. On some instruments a wick oiler is used. In this case use pure vaseline instead of grease.

Manufacturers are Remy Electric Co., Anderson, Ind.

†Westinghouse Ignition System.

Battery and coil ignition system is of the **closed circuit** type (see chart 118). It is made for 4, 6 and 8 cylinder engines.

The timer-distributor unit is vertically mounted and is operated from the cam shaft or can be attached to generator, as all other systems of this type can be. Only hand operated advance is provided.

The **condenser** is mounted close to the breaker mechanism, being below the coil and distributor. Note the **condenser, coil and breaker are all in one unit.**

A metal ring can be slipped upward to **permit inspection** or adjustment of the contacts.

The distributor is the same as that used in the regular Westinghouse systems in which a circular carbon brush make contact with terminals embedded in the cover.

The standard ignition switch is of the snap type and combines the lighting switches in one plate which is mounted flush on the dash. Each time the ignition switch is turned the polarity of the current is reversed, therefore it would be termed a **polarity switch** (see chart 117 for principle).

Westinghouse adjustments: In **adjusting the breaker** the contacts should be dressed with a fine file and adjusted so that the maximum opening is .008 in. **Spark-plug gaps** should be .025 in.

The distributor brushes should slide freely in their holder and the spring should push the top brush out so as to extend from the holder about ¼ in. when the distributor plate is removed.

In the back of the switch plate there is what is termed a "ballast coil" (for same purpose as "thermostat"—chart 119). This is a small resistance in series with the final winding, and is to protect the winding and prevent excessive draw on the battery, should the engine remain idle with the switch in the "on" position. If this should be accidentally broken the ballast terminals may be temporarily short-circuited with a piece of wire or with a standard 5-amp. fuse.

The only lubrication required will be two or three drops of oil about once a month in the oil cup provided on the side of the distributor unit.

Manufacturers are Westinghouse Electric Co., Pittsburg, Pa.

The Connecticut Ignition System.

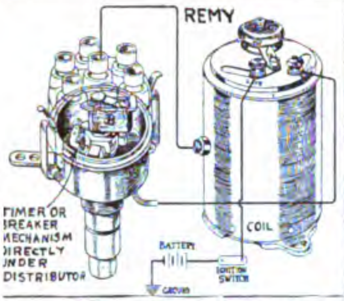
Is a typical example of a closed circuit type and is made for 4, 6 and 8 cylinder engines. This company calls the interrupter and distributor, which is mounted in one unit—an "igniter." They also term the timer, interrupter, because it is similar to a magneto interrupter—which interrupts the flow of current—however, other systems as the Remy and other closed circuit battery and coil ignition systems also call the timer, interrupter, as it is exactly the same principle. (see pages 252, 254, 364 and 358.)

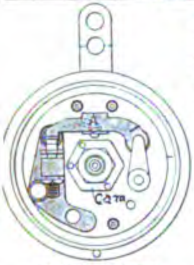
---

*See charts 229-234 for "Specifications of Leading Cars," for cars using these different systems. Also Instruction 28, and "Standard Adjustments of Leading Cars," chart 228.

**See page 318 for example of timing Remy ignition on Chalmers.

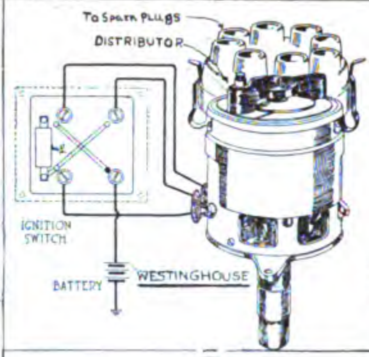
*See also pages 346 and 348.

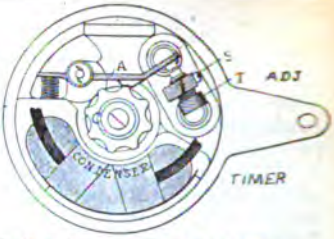




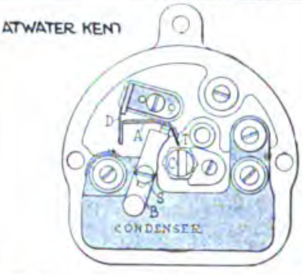
The Remy system operates on the closed-circuit principle and has not been altered greatly in the last year This drawing shows the method of wiring the system and the interrelation of its various parts

REMY CAM ACTION
When the Remy cam C is rotated it touches the fibre block in the contact arm A, thus separating the contacts. This is a closed circuit system

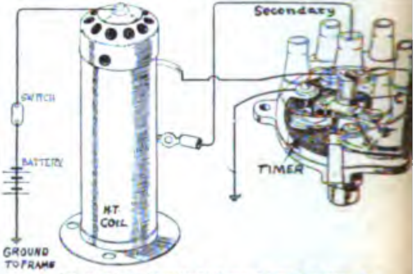




The Westinghouse system operates on the closed circuit principle and has undergone no great change Rotation of the cam C brings it in contact with the block on the contact arm A, thus separating the contacts which are normally together Adjustments are made by loosening the clamp screw S and turning the milled nut T

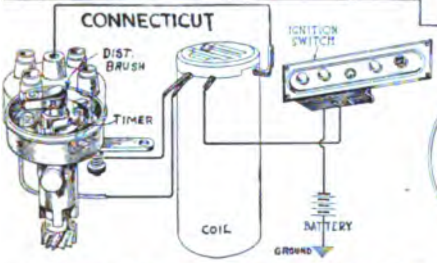


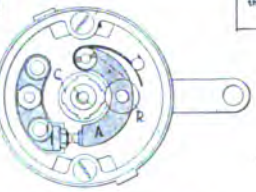
Mechanism of the bearingless breaker of the Atwater Kent closed circuit system



The Model CC Atwater Kent closed-circuit system is compact and wiring is reduced to the minimum

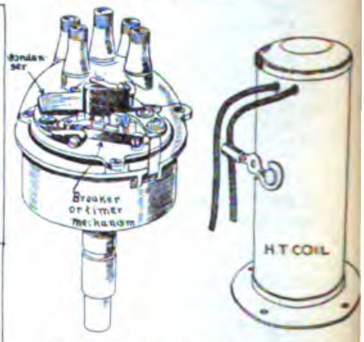
MODEL CC ATWATER KENT BREAKER
The contacts are normally closed by the spring D. Rotation of the cam brings it in contact with the fibre tip T on the contact arm A, thus separating the contacts and breaking the circuit. Adjustmens are made by loosening th screw S and moving the arm B



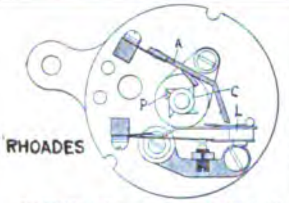


The Connecticut system operates on the closed-circuit principle, rotation of the cam C bringing its high spots in contact with a fibre roller R in the contact arm A. This separates the contacts which normally are held together

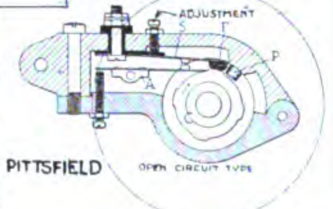
In principle this has not been altered, though the whole device now is stationary, not even the wires moving when the timing is advanced.



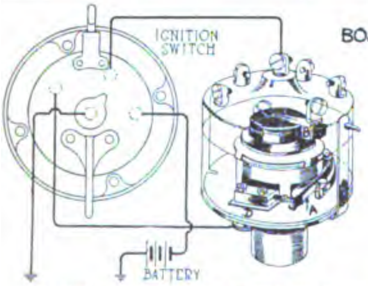
The Model KA Atwater Kent open-circuit system showing new location of the condenser near contacts

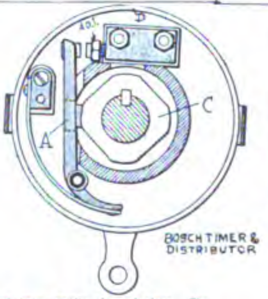


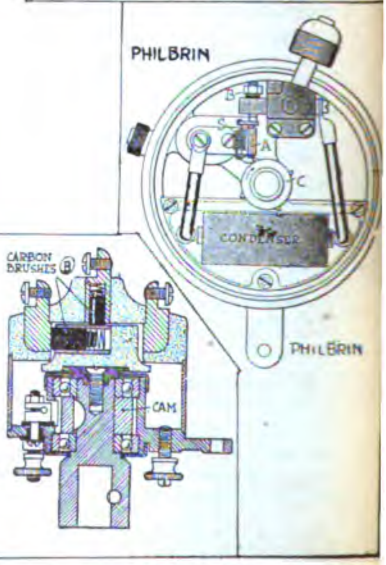
The Rhoades system is new in construction but the same in principle; the mechanism has been considerably simplified. Above is shown the action. When the cam C is rotated by the pin P it strikes the projection on the arm A pushing the arm out and permitting it to fly back. The momentum of the arm causes it to strike the contact arm L thus momentarily bringing the contacts together This is an open-circuit system



The Pittsfield breaker is unique. The contacts are brought together and separated mechanically without the aid of a spring. When the cam C is rotated, its high spots first touch the lower arm A, bringing the contacts forcibly together and holding them until the cam rotates further against the block F, and thus forcibly separating the contacts again. The plug P is merely oily felt for lubrication







The Bosch battery ignition system, developed nearly 10 years ago, has not been greatly changed since. The wiring is simple. In operation, rotation of the cam C brings it against the fibre block in the contact arm A, thus separating the contacts which are normally closed by a spring

CHART NO. 118—Examples of Open and Closed Circuit Coil and Battery Ignition Systems.

page 543 for "Specifications of Leading Cars" for Ignition systems used on leading cars and "Standard instment of Leading Cars." page 542. for timer adjustment, also pages 250, 254 and 378.

Example of Timing Connecticut Ignition System.

By referring to chart 119, the Connecticut system is made clear. Note the thermostatic principle used with this system.

To time breaker and distributor (Mitchell six, as example). When replacing, if for any cause it becomes necessary to remove breaker and distributor, crank engine by hand until piston of No. 1 cylinder (first from front end of car) comes upon its compression stroke and stop when the 1-6 mark on flywheel is on top in a line with flywheel indicator. At this point the piston is at the uppermost point of the compression stroke or "dead center." You can determine when the piston is coming up on the compression stroke by opening the relief cock on the cylinder and holding your finger over the opening.

Now advance spark lever on the steering wheel one-quarter of the way. Remove distributor cap, then set the combination breaker and distributor on driving shaft with set screws loose, connect advance lever, turn hub on the shaft, in direction of rotation (anti-clockwise) until contact points are just opening, which is the point at which the spark takes place, then tighten the hub set screws.

Now replace the distributor cap, carefully noticing which segment of the distributor brush is opposite, for this is the connection to the spark plug of No. 1 cylinder. Now connect up the balance of the spark plugs in their firing order—1, 5, 3, 6, 2, 4.

On the Dort car which uses this system, the piston is placed on top and spark lever retarded.

The Chevrolet timing: Place piston on top of compression stroke. (See fig. 19, page 636.) Retard spark, loosen set screw and turn igniter unit until contact points are just opening, which is the point for spark. Tighten the set screw. **The firing order** is 1, 2, 4, 3. Therefore connect plug terminals accordingly. (see chart 179.)

Testing Ignition Circuits and Parts.

This not only applies to the Connecticut system, but to other systems of the same kind. Also see chart 192 and pages 249, *235.

Testing coil: In order to determine if the coil is operating properly, secure a piece of wire and, holding one end to the frame of car, engine casting, or other metallic "ground," bring the other end to within one-quarter inch from the point where the high tension wire (running from the coil to the central terminal of the igniter) leads from the coil, and turn the engine over by hand with the switch on. If a spark occurs at this point and not at the igniter, the trouble is in the high tension wire which leads from the coil to the igniter. If, however, no spark occurs at either point, see if the safety gap in the top of coil is wet. In this case dry out the coil for several hours in a warm oven. The safety gap may be observed by removing the cover on the top of coil.

If this does not correct the trouble and the primary circuit is intact it is evident that the coil should be replaced or returned for repairs.

It is a good plan to regularly examine the clamping rods holding the coil to the generator, **tightening** when needed to prevent vibration from loosening the terminals or breaking them.

Test of primary circuit: When testing the primary circuit there are practically only two things to be taken into consideration, namely, the condition of the contact points in the breaker box and the wiring.

When tracing the primary circuit, first see if any of the fuses have "blown," then trace all the wiring of the ignition circuit.

Testing Ignition switch: In order to test switch and determine if current flows through it, attach a wire to the negative terminal on the storage battery and remove the wire from terminal on coil. Then push the ignition button on left end of switch in and make and break the circuit with the two wires by touching their free ends together. If a spark occurs, there is a circuit through the switch. If a spark is not obtained there is doubtless an open circuit in the interior, therefore it should be returned for repairs.

The Bosch Ignition System.

The battery ignition system developed by the Bosch Magneto Co., nearly ten years ago has not been altered greatly. It operates on the **closed-circuit** principle and is supplied for two, three, four, and six-cylinder engines.

The complete system consists of a combined timer and distributor and a combined switch and coil, the latter to be mounted on the dash.

The breaker mechanism is simple, rotation of the cam C (see chart 118), pressing a fibre block separates the contacts which are normally closed by a spring.

The distributor is fully as simple and is mounted directly over the breaker. Only hand operated advance of spark is provided.

The switch incorporates the vibrator attachment to facilitate starting when the engine is cold or the carburetor out of adjustment. This mechanism is controlled by the pointed button in the center of the switch plug. Under normal starting conditions momentary pressure on the button will produce a single spark at the plug. Turning the plug to the right and depressing it makes the necessary connection to provide **a continuous stream of sparks** at the plug. If desired the button can be locked in this position until the engine has started.

The switch provides for the use of a magneto, the engine running on the magneto with the switch in one position and on the battery with the switch in the other position.

There is only one adjustment, and this is for the gap at the contacts. With the fibre block resting on top of the cam, the contacts should be separated about .01 in. To alter the adjustment the lock nut must be released first, and carefully secured after the adjustment is made. Occasionally expansion of the fibre bushing prevents the free movement of the lever, and in this case the bore of the bushing can be slightly enlarged with a reamer. No lubrication is required.

Also see chart 133, fig. 3, and instruction 21, for diagram, etc., of the Bosch battery and coil system.

Delco Ignition System.

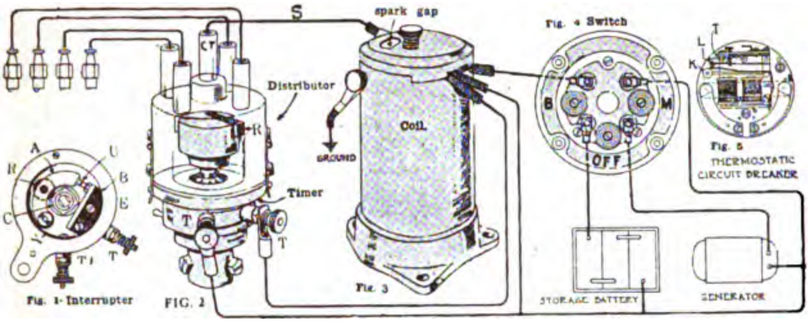
The Delco coil and battery ignition system is another popular system. It is treated under instruction number 28-A, and is made in both the **open** and **closed circuit** principle—see pages 377 and 378.

---

*Note.—The coil and battery ignition systems treated under this instruction are also treated further on under instructions number 27 and 28.

Connecticut Battery and Coil Ignition System

is used on the Overland, page 358 and Chev rolet, page 364 and many other cars.



Interrupter is of the closed circuit principle as explained on page 243. Note it is mounted under distributor (fig. 2—upper illustration). **Cam** (C—fig. 1), is provided with **as** many lobes **as** there are cylinders. **Platinum points** (U) are separated by **arm** (A), raised by cam (C) operating against **a fibre** roller (R). Terminal (T1) connects with **point in** arm (A) through contact strip (Y). Contacts **are** closed until separated by cam (C). Both **points** are insulated.

Primary connections to interrupter is made from coil to (T and T1), which connect with A and B. See page 358, for internal wiring diagram as applied to the Overland.

Distributor

is mounted above interrupter (fig. 2). A "brush" type contact (R) is used on this model. On later models (see page 252) the "gap-type" is used as explained on page 247. Interrupter and distributor are driven at cam shaft speed. **To time spark see** pages 358, 364 and 253.

Coil

is the usual non-vibrating type (fig. 3). To understand the 5 wire connections to it, see page 248 of another similar system. On model shown on page 252 there are but 4 connections to coil—see also page 358 for internal wiring. **A spark gap** is provided which affords protection in case high tension wire comes loose (see page 273 for principle).

Adjustment

There is but one, which is the opening of contact points (U), which should be .018 for a 6 cylinder engine and .020 for a 4 cylinder engine. When adjusting, roller (R) should rest on point of **cam** (C). **Points (U) do not require re-fitting,** even though rough, but if too badly burred, as to cause missing—install a new "breaker plate"—as shown in figs. 1 to 8.

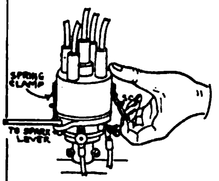


Figure 1.
Unclasp spring hinges on the side of ignitor.

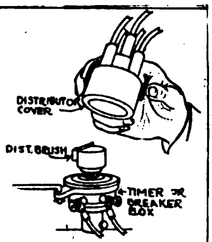


Figure 2
Remove distributor case and wires.

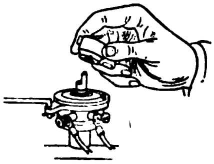


Figure 3.
Remove distributor arm

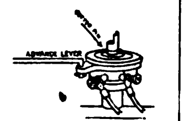


Figure 4
Remove advance lever and take out cotter pin passing through shaft.

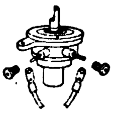


Figure 5.
Take off primary wires.

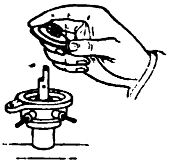


Figure 6.
Lift cover from breaker box.

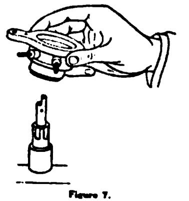


Figure 7.
Take breaker box from shaft.

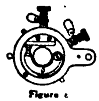


Figure 8
Front view of the breaker box after being removed from the shaft.

Thermostat.

Is enclosed within rear of the switch fig. 4. See page 358 and note on the Overland it is in the "combination switch" box on steering column with ignition switch.

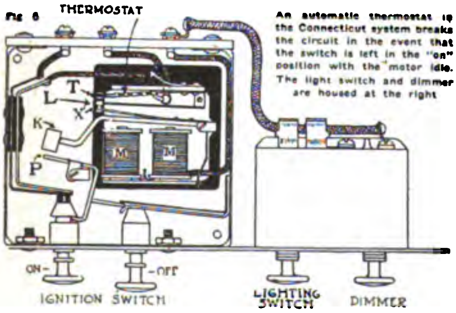
Its purpose is to open the circuit, should the switch be left on when engine is not running, as explained on page 246.

The thermostat consists of the blade—T, (see figs. 5 and 6), which heats when the current passes through it for from 30 seconds to 4 minutes without interruption and causes it to bend downward, making contact with the contact (L).

This completes an electrical circuit which energizes the magnets (M). causing the releasing hammer (K). to operate like the clapper in an electric bell. This arm strikes against a plate (P) which releases whichever of the two ignition switch buttons in the switch may be depressed or "on." Thermostat can be set to act from 30 seconds to 4 minutes.

An adjusting screw (fig. 5), is provided directly over thermostat spring (T) which regulates the time. If thermostat was made to disconnect in less than 30 seconds it would probably "kick-off" when putting on ignition, before engine could be started.

Fig 6



An automatic thermostat in the Connecticut system breaks the circuit in the event that the switch is left in the "on" position with the motor idle. The light switch and dimmer are housed at the right

CHART NO. 119—Connecticut Coil and Battery System—Example of a Modern Closed Circuit Interrupter. (Conn. Telephone and Elect. Co., Meriden, Conn., Mfgr's.)

Above system model 15 with carbon brush—(R, fig. 1). See page 252 for model 16 distributor. See also **pages** 1. 358 and 364. The "gap-distributor" is used on late systems—see explanation page 247.

INSTRUCTION No. 20.

A BRIEF REVIEW OF THE VARIOUS COIL IGNITION SYSTEMS: Advantages and Disadvantages. Dual and Double Ignition System. The Ideal Electric Systems.

We have now mastered the various methods of producing an electric spark for igniting the gas with a "primary" or low tension coil and a "secondary" or high tension coil. Before proceeding with the subject of magneto ignition ("alternating" mechanical source of electric supply), we shall summarize the various systems.

Low tension coil systems; disadvantage of the "make and break" is its lack of "flexibility" and slow spark. It would be considered fairly good for a slow running constant speed stationary or marine engine.

****Coil with vibrator**; disadvantage of a vibrator coil is its tendency to miss; if battery is weak, vibrator will not operate—if too strong, points on vibrator will weld together and stick, causing missing. Spark is not fast enough. Consumption of current rather heavy. See page 250 for "succession of sparks and single spark."

Master vibrator coil—(chart 110); where a system is already equipped with a multiple of vibrator coils, this would be an excellent method to improve it. Disadvantage—sticking vibrator—all work on one vibrator—succession of sparks.

Dry battery as source of electric supply—disadvantage is unreliability. A battery of 5 or 6 dry cells will do fairly good work when fresh for short periods of time—provided two sets are used and the use alternated from one to the other. It gets weaker as used, however, and is unreliable. Intended for "intermittent" work—as ringing door bells, etc., where used only for a few seconds or so at a time (see fig. 3, chart 102).

Storage batteries—are better as they maintain their pressure until exhausted. Contain greater quantity of current and are far more satisfactory—disadvantage—must be recharged when exhausted and operator must watch it for fear of running down.

Battery, coil and magneto—if the generator is a magneto, the dry cell or storage battery and coil could be used for starting. After starting, the storage battery and coil is cut out and magneto generates current. Disadvantage—all magnetos do not generate a strong current when running slow. Troublesome vibrator coil.

Magneto alone—a magneto of the high tension type would be a fairly satisfactory system. It is an improvement over the low tension magneto—as a separate coil is not necessary. Disadvantage—when starting the armature of magneto must be turned fast enough to generate current, therefore difficult to start with. On slow running or idling the current is weak on the average make.

Dual system of ignition: Where a car has two ignition systems for instance, a coil and battery and independent magneto, but both systems using one set of spark plugs—this system is called a "dual" ignition system.

Double system of ignition: Where two sets of spark plugs are used with two independent ignition systems—this is called a "double" system.

The Ideal Electric System.

For ignition, lighting and starting would be a coil without vibrator used in connection with a "single spark" timer. Storage battery for electric supply for starting and lighting. Dynamo operated by engine to recharge storage battery and supply current for ignition and light after engine is started. **Advantages** of this system are apparent—the chief advantage being a "**constant**" source of electric supply and the next; an ignition system capable of giving a fat hot spark at the **right** time regardless of speed of engine (see charts 117 to 119).

Disadvantage would appear to be (1) the probabilities of the dynamo at high speed burning out the coil, as the voltage increases with speed of dynamo—or (2) when running slow, the connection being between the storage battery and field coils—current would flow from battery into generator. This, however, is all taken care of (1) by "regulation" of the dynamo field windings so the output remains constant at low or high speeds (2) by a "cut out" arrangement—all of which will be explained under instructions 26 and 27.

Starting—as we are provided with a constant source of electric supply—a starting motor can be connected to engine as explained under instruction 26.

---

*See "Specifications of Leading Cars," pages 548 to 546 for ignition systems used on leading cars.
**See page 248; and note a vibrator coil would have an "electrical and mechanical lag."

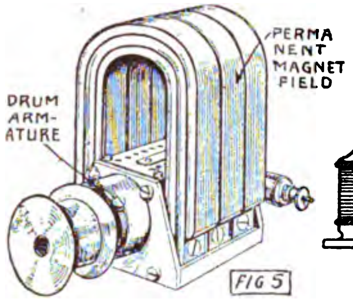


FIG 5

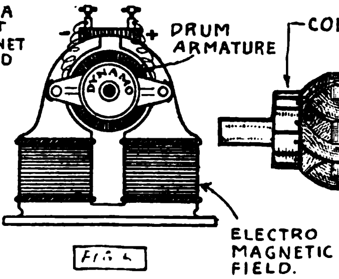


FIG 6

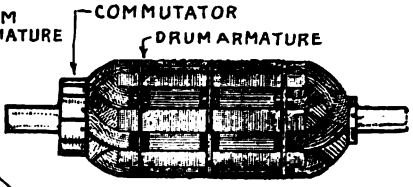
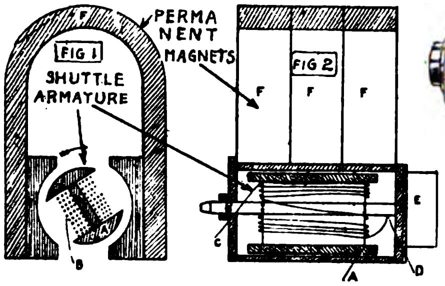


FIG 7

Fig. 5. A dynamo or mechanical generator of "direct" current. Note this type of generator **can have** either "permanent" or "electro" magnets, but the armature is always DRUM wound with a commutator on end of armature shaft.—see pages 323, 325, 332 for drum armatures.

Permanent magnets are of the horse shoe type and are permanently magnetized. They are called **the** "field" magnets.

Electro field magnets are wound with copper wire and are electrically magnetized and remain magnetized only when armature revolves between the field magnet poles. This type of dynamo or generator, generates a steady "direct" current, usually of 6 or 8 volts and will light electric lamps **and** recharge a storage battery and supply current for ignition. It is usually run in connection with **a starting** and lighting system, and in smaller models, is used for ignition on stationary and marine engines to a considerable extent.



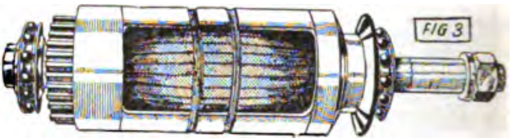


FIG 3

SHUTTLE TYPE ARMATURE WITH ONE WINDING - LOW TENSION

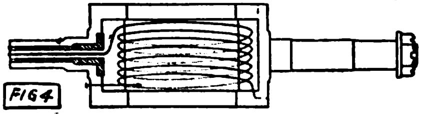


FIG 4

Fig. 1. The magneto is also a mechanical generator, but the current generated is "alternating," that is, the current is not a steady flow, but alternates continuously. The field magnets are always of the permanent magnet type. The armature for generating alternating current is of two types; the "shuttle" type as shown in figs. 3 and 4 or the "inductor" type as shown in fig. 8.

The shuttle or "armature" type of armature (see page 274) has a primary wire winding of copper wire, one end grounded to armature core and other end insulated. If there is but one winding on the armature it is called a "primary" winding and is of low voltage; about 6 volts. Therefore it is called a "low-tension" magneto. If there are two windings on armature it is called a "high-tension" magneto.

Fig. 8: the "inductor" type of armature: The wire is stationary and the inductors or "rotors" revolve, whereas on the "shuttle" type the armature and wire revolve. The latter type is more generally used.

***The K. W. magneto is a leading magneto of the inductor type. Construction;** magnets, permanent type; pole-pieces placed above armature 90° apart; rotors set 90° apart. There are two rotors with 4 ends. **Fig.** 8 illustrates the arrangement of rotors on armature shaft. This gives the same effect as if two shuttle armatures were placed cross wise—which would be 4 impulses per rev. (fig. 10) instead of 2 in the shuttle type (fig. 9). If we continued adding we would soon have the alternations so close together we could light an electric lamp—in fact, the K. W. low tension magneto at high speeds will accomplish this.

The coil on the K. W. is stationary and rotors revolve. With a single primary winding on coil core it is a low-tension magneto. With two windings, per page 288, fig. 6, is then a high-tension magneto.

Fig. 8A, shows lines of force passing **down** through rotor wing from N pole, then centrally through core over which coil is placed, up rotor to S pole.

Fig. 8B, shows rotors moved in position where lines of force are now passing in reverse direction, which causes a complete reversal of polarity through coil winding. **This is maximum position** and where contact points (P) should separate—see page 296, which is a high-tension type.

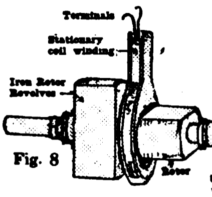
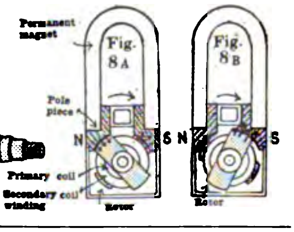
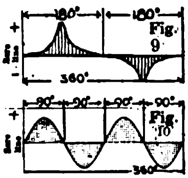


Fig. 8





Impulse diagram.

Fig. 9: Shuttle, or "armature" type magneto (see page 274); produces 2 impulses or **waves** of current of maximum intensity per rev. (360°). Note direction is changed each ½ rev. or 180° (see pages 266, 267).

Fig. 10. The K. W. inductor type armature produces 4 impulses or waves per rev. Note direction of flow of current is changed 4 times or at each ¼ rev. or 90°.

CHART NO. 120—Mechanical Electrical Generators of "Direct" and "Alternating" Current.

*See also pages 264, 288, 296 and 832.

INSTRUCTION No. 21.

*LOW TENSION MAGNETOS: Construction. Parts, Principle. Magneto Action. Explanation of Impulse and Waves of Current. Low Tension Ignition Systems. Inductor Type Low Tension Magneto. Ford Magneto Principle.

We will now take up the "mechanical" source of electric supply for the different ignition systems.

A device for generating electricity mechanically is called a dynamo or magneto. The kind of current the dynamo generates is "direct" current and the magneto generates "alternating" current.

The direct current dynamo generator is usually called a "direct current generator or dynamo" and is usually applied to generators run from the engine which supply current for charging the storage battery, for lighting, also for ignition.

This type of generator can have either "permanent" magnets or "electro magnets" for the magnetic field, but in every instance, the armature is a "drum" wound armature. This type of generator generates a low tension or voltage, usually 6 volts.

The alternating current generator is always called a "magneto," because the field magnets are of the permanent magnet type and the armature is either a "shuttle" or "inductor" type. This type of generator generates nothing but an "alternating" current, suitable only for ignition. Alternating current will not charge a storage battery.

Alternating current generators are divided into two classes; the "low tension magneto" and the "high tension magneto."

We will take up the construction of the low tension magneto first, because the high tension is really a low tension magneto, but with a double winding on the armature. Therefore, starting with the low tension magneto first, it will then be easier to master the principle of the high tension magneto later.

Magneto Construction—Low Tension.

The principle of a low tension magneto is similar in many respects to a low tension coil as described on pages 215 and 214. In a magneto the armature on which the primary wire is wound is called upon to produce its own electric supply, whereas in a primary or low tension coil the electric supply is from another source. See fig. 1, page 260.

Field magnets: Therefore, permanent magnets (1a), called the "field magnets" are provided as shown in fig. 1, chart 121. The pole pieces (11a) provide a magnetic field for the shuttle type armature (fig. 4) to revolve in. End plates with ball bearings are attached to screw holes in pole pieces (11a, fig. 1). There is very little clearance between the armature and the poles, therefore accurate fitting is necessary.

The magnets; usually two, four, or six, are placed over the pole pieces; all north poles on one side and all south poles on the other side. The base (12a, chart 121), is usually made of brass or aluminum, as neither will become magnetized.

The armature is explained in fig. 6, chart 121. This has a single winding of coarse wire (usually about No. 18, insulated), called a "primary" winding similar to the primary winding on a coil.

On a high tension coil system, one end of the primary wire leads to a commutator or timer, and the other end to a battery. When the circuit is closed and suddenly broken the current is "induced" in the secondary winding as previously explained.

On a magneto, the primary winding is closed, and the sudden opening or "interruption" of the flow of current in the primary winding at certain times (see page 267) intensifies the current.

This interruption of current can be accomplished in two ways; by "breaking" the current with an "igniter" suddenly, as in fig. 1, page 260.

Or by "interrupting" the current with a "contact breaker or interrupter" as per fig. 3. Therefore; we have two methods of intensifying the low tension current of a low tension magneto.

The first method is similar in action to snapping two wires together as explained in fig. 6, page 214 and illustrated in fig. 1, page 260. The interruption is made by an igniter, operated by a cam on cam shaft.

The second method is similar in action and is explained in fig. 3, page 260.

It must be borne in mind that the time the interruption takes place is when the armature is in a vertical position, for at that time the strongest current will be available. (explained further on.)

The armature is in a vertical position twice during one revolution, therefore we can make two interruptions during one revolution, by having a "two point" cam raise the interrupter arm at the right time.

If a single cylinder engine, only one nose on cam is needed.

If a four cylinder, four cycle, we need 4 sparks during two revolutions of crank shaft, therefore the cam would have a double nose and would run at the same speed as engine crank shaft.

---

*This system is now seldom used, but must first be understood before reader can properly understand the high tension magneto.

**All low tension magnetos are not driven at fixed speed. See K. W., page 265.

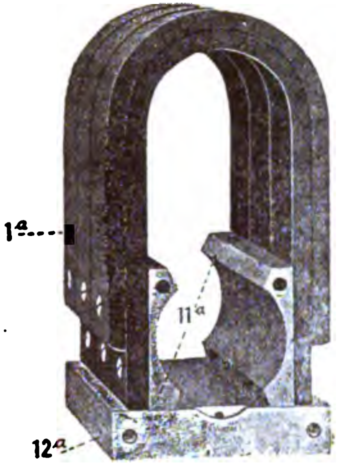


Fig. 1—Permanent magnets (1a); pole pieces (11a); base of brass or aluminum (12a).

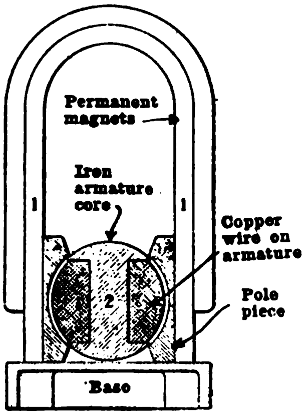


Fig. 2—View of a low tension magneto with the end plate off and armature shown in section.

1—Permanent magnets (magnetized at all times).

2—The armature, revolved by a gear connected with engine shaft.

Note that a single winding of insulated copper wire is wound on the armature.

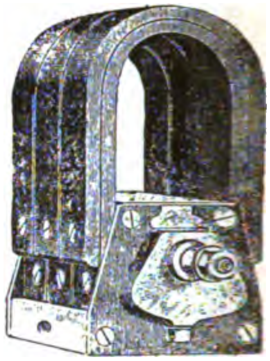


Fig. 3—The low tension magneto complete. View shows the drive end of the armature, which is driven at a fixed speed from crank shaft of engine, by gear or chains.

The armature has one winding.

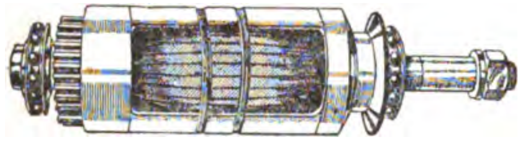


Fig. 4—The low tension magneto armature with a single winding, called the primary winding. The armature revolves between the poles 11a. This type of armature is called a "shuttle" type, also called "armature" type, see page 274.

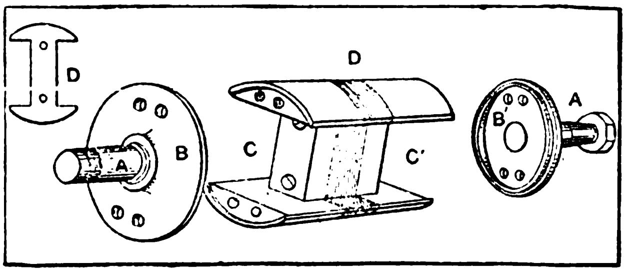


Fig. 6—Parts of the low tension magneto shuttle type armature.

This type of **armature** is called a "shuttle" or "H" type. Bronze heads (B B') are screwed to the armature core (C and C').

Shafts (AA) are driven and riveted to bronze heads. Wire is wrapped around space (C C'), called the core.

It will be seen that the core is not a solid casting; rather it is a pair of castings between which is clamped a group of soft iron stampings (D), having the form shown in the detail sketch. The object of thus laminating the core, as it is called, is to retard the circulation of "eddy currents" in the core due to induction. The same forces of induction which are at play in the windings, operate also in the iron core itself, and if unchecked would both consume power and heat the armature unduly. As the voltage of these currents is very low, even the slight obstruction of the laminations is sufficient to retard them.

The **laminated** section of the armature is shown at (D). Laminated means that instead of the castings (C) being solid there are several layers of flat sheet iron placed together, between the cores (C), as shown at (D).

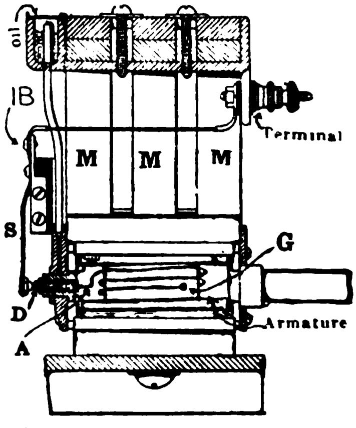


Fig. 5.—Sectional view of a low tension magneto, showing one method of conducting the low tension current from armature; one end of **primary** winding, which is heavy, **coarse wire** is grounded to armature core **at (G).** The other end (A), is **insulated and** passes through the hollow end of **armature shaft and makes contact with a** point (D), (see **also fig. 4, page 256).**

As the **armature revolves, the spring** (S), which is mounted on an **insulated** block (IB), conducts the **current** through a wire connected **with it, to** terminal. ("Collector rings," **similar** to one on the high tension **magneto**, fig. 1, O and P, page 268, **are also** often used.)

From the terminal the **current** is carried to the "igniter," as per **fig.** 1, page 260.

It will be noted that a separate low tension coil is not necessary in this instance, as the winding on **armature** takes its place.

If the low tension magneto is used with a separate high tension coil, as per fig. 8, page 260, then this **wire A** from armature would go to the **primary** winding of coil.

HART NO. 121—Construction of a Low Tension Magneto.

Low Tension Magneto Supplying Current for a "Make and Break" Ignition System.

On page 217, this system is explained. The magneto however, was not explained, therefore if the reader will refer to page 258 and 257, the principle of the low tension magneto will be made clear.

It is well to bear in mind that a low tension magneto used in connection with the low tension "make and break" system, shown in fig. 1, page 260, **does not require a low tension coil,** because the action of intensifying the current as explained in fig. 6 page 214, is obtained by the snapping of the "igniter" points (M), fig. 1, page 260, by action of a cam, and the winding on armature of the low tension magneto takes the place of the low tension coil. By referring to page 257 and fig. 1, 260, other details which are simple, will be made clear.

Low Tension Magneto and High Tension Coil.

The low tension magneto can be used in connection with a high tension coil and produce a "jump-spark" or high tension spark at points of a spark plug in cylinder, by using the low tension magneto to produce the current, and a separate high tension coil (without vibrator) to intensify the low tension current to a high pressure, so that it will jump gap of spark plug.

We would need for this system a high tension coil, a distributor on the magneto to distribute the high tension current to the spark plugs (if a multiple cylinder engine, which in this instance, we will say, is a 4 cycle, 4 cylinder) and an **interrupter** to break the low tension current at the proper time.

Coil—the double wound high tension coil, **similar** to the coil explained on page 220, **fig.** 1, but **without a vibrator** can be used. The interrupter will take the place of the vibrator, therefore we would have a single spark instead of a succession of sparks. When the contact points separate, as explained under "interrupter," the low tension magneto current is intensified, and "induced" current is set up in the secondary winding as explained on page 220. This coil can be placed separate from magneto as per fig. 3, page 260.

†**Distributor:** this "induced" or high tension current is then distributed to the spark plugs in correct firing order, by distributor rotor and brush per figs. 1, 2, this page.

The distributor is driven at one half the speed of armature (see page 261).

***The interrupter,** see fig. 2, above, and fig. 3, page 260, is mounted on the front end of magneto armature shaft. The housing on which interrupter parts are mounted, can be shifted, by means of a rod (SL) fig. 2. This rod connects with spark lever on steering wheel—see page 294.

Therefore the time for the spark to occur can be made early or "advanced," or late or "retarded." The usual range of advance on a magneto being from 22° to 35°.

Attached to the housing and moving with it, is the interrupter arm (A) and the insulated terminal (B).

On the end of the interrupter arm (A) is a platinum point (P). There is also another platinum point (P) on terminal (B).

Platinum is used because there is more or less sparking occurring at the points and platinum being hard, it stands the spark with less pitting than other metals (see "polarity switch," page 248).

‡**The condenser** in the coil (explained in fig. 5, page 228), takes up excess sparking to a great exent. Condenser can be placed in the coil box per pages 262, 263, or in the magneto if magneto is a high tension type—per (J), page 268. See also pages 274, 273.

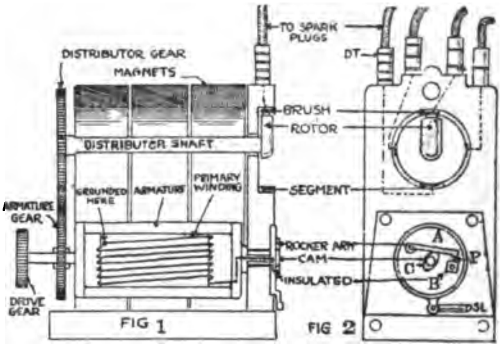


Fig. 1—Note how distributor shaft is driven by gear on armature. Fig. 2—Front view of distributor and interrupter.

The cam (C) is attached to the front end of the armature and revolves with it (see figs. 1 and 2, and fig. 3, page 260).

When the nose of cam (C) raises the interrupter arm (A), the current is interrupted in the primary winding causing the high tension current to be set up in the secondary winding of the coil.

The cam has two lobes, therefore it will raise the interrupter arm twice during one revolution, or four times during two revolutions of armature. Armature would then run at same speed as engine crank shaft. (see page 261). As it is attached to the armature it must revolve with it.

The cam is set on the armature, so that the nose will raise the interrupter just as the armature passes **vertical position.

If the cam raises the interrupter arm (A) when armature is in this position and the interrupter housing is at full retard position, this will then allow for advancing of the spark full 35 degrees or less according to range of magneto. (see page 309.)

The primary circuit on the armature of the low tension magneto consists of a winding of several layers of coarse wire B, fig. 3, page 260. One end is grounded to the armature core and the other end is insulated, and connects with primary winding of coil.

---

*There are many types of interrupters. One used in this example is simplified to explain the principle. (see page 298.) ‡**A condenser,** although not shown, is always connected around interrupter points. If low tension magneto, it is in the coil per pages 262, 263. If high tension magneto, it is in the magneto, per pages 268, 274, 278—yet it serves same purpose.

**See also, instruction 24, Ignition Timing. †—by referring to page 262, fig. 23, method of conducting current from a separate coil to distributor arm or rotor, on magneto is shown clearly.

"Make and Break" Low Tension Ignition System; Using a Low Tension Magneto To Supply Electric Current.

Low tension magneto to supply current for the "igniter" as shown in fig. 1 **and explained on page 259.**

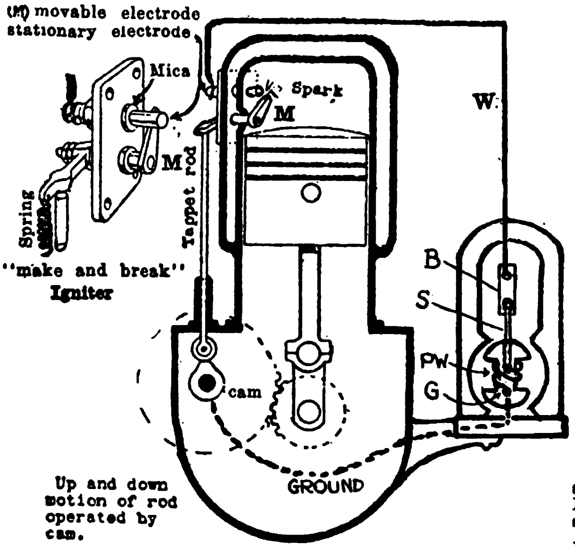


Fig. 1.—One method for intensifying the current from the low tension magneto is to suddenly break the flow of current as explained in fig. 6, page 214. Instead of breaking the flow by hand, however, the make and break type of "igniter" is used. A low tension coil is not used with above system as the winding on magneto takes its place. (see fig. 5, page 258, for names of parts of magneto.)

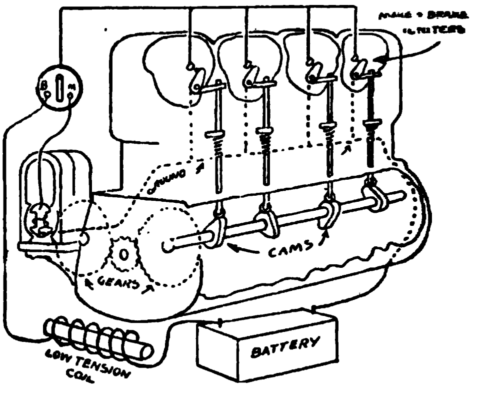


Fig. 2.—The low tension magneto ignition on a multiple cylinder engine. Battery for starting. Magneto armature revolves same speed as crank shaft of engine.

Note that a low tension or single wound coil must be used in the circuit if the battery is used, whereas if magneto is switched on instead of the battery, the winding on the armature acts as a coil instead. Note a cam shaft operates the "make and break" igniters, which govern the time of spark, causing four sparks during one revolution of cam shaft, or two revolutions of crank shaft.

On above system, armature is driven at a fixed speed, because it is of the "shuttle type." The cam snaps the igniter arm (M) when piston is on top of compression stroke. Therefore armature must be in a vertical position, just leaving the pole (see pages 266, 267 and 309). See also pages 257, 259, 261 for relation of speed.

Note—all low tension magnetos are not driven at fixed speed—see K. W., pages 264 and 265.

A "High Tension" Ignition System Using a Low Tension Magneto to Supply Electric Current.

This system is fully explained on page 259. It is similar in many respects to the battery and coil system described under Instruction 19, except a low tension magneto supplies the current instead of a battery, and the *interrupter and distributor are mounted on the magneto instead of being driven separate. The objection to this system is explained on page 261. Also see pages 261 and 259 for relation of speed of armature, distributor and engine crank shaft.

This system is slightly different from the one shown at bottom of page 262, where the interrupter or contact breaker is shunted across the primary circuit. With above system it is in series.

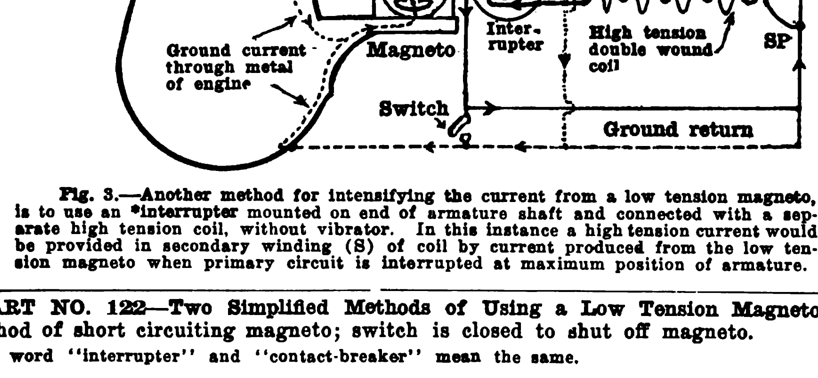

Spark plugs
Gap
Engine
Secondary wires to spark plugs
D
Distributor on magneto
S
P
R
A
B
G
Ground current through metal of engine
Magneto
Inter-rupter
High tension double wound coil
SP
Switch
Ground return

Fig. 3.—Another method for intensifying the current from a low tension magneto, is to use an ***interrupter** mounted on end of armature shaft and connected with a separate high tension coil, without vibrator. In this instance a high tension current would be provided in secondary winding (S) of coil by current produced from the low tension magneto when primary circuit is interrupted at maximum position of armature.

HART NO. 122—Two Simplified Methods of Using a Low Tension Magneto. Note in fig. 3, method of short circuiting magneto; switch is closed to shut off magneto.

The word "interrupter" and "contact-breaker" mean the same.

The armature revolves, therefore the end of the armature primary winding (R), from which the low tension current is taken, is carried through end of armature shaft (insulated), similar to D, fig. 5, page 258, but where an interrupter is on armature it is arranged similar to K, fig. 2. page 270, but not connecting with any other part than the wire from armature. This spring contact conveys the low tension current from armature, which revolves, to primary coil winding P, fig. 3, page 260.

Note arrangement of interrupter on page 270. It is a different construction from fig. 3, page 260. The interrupter on page 270 is more modern. The one used in fig. 3, page 260 is simplified.

The current is then carried through primary winding P, to insulated terminal B, through interrupter points P (which open when armature is in maximum position), to arm A to ground G, back to magneto ground. This completes the primary circuit of magneto and high tension coil.

Trace arrow points from upper primary wire from magneto armature, back to magneto ground for the primary circuit.

The secondary current (fig. 3, page 260), starts at distributor brush (D) to insulated part of spark plug, jumps the gap, thence returns from metal shell of spark plug, to "ground" connection on engine to secondary and primary connection on coil (S-P) through secondary winding (S) back to distributor brush (D).

Magneto switch (fig. 3, page 260) is open when the magneto is working, but **to stop the magneto from generating current, the switch is closed** or "short circuited." A glance at the illustration will shew how the armature is short circuited, therefore "interruption" of current cannot take place—see also page 275.

The magneto must be driven at a fixed speed because the interrupter and position of armature govern the time of spark. Therefore, the magneto is either driven by a chain or a gear from the cam shaft but not by belt, see page 295, "magneto speed."

Magneto Distributor Parts.

***The purpose of the "high tension" distributor** is to distribute the high tension current to the spark plugs. The distributor brush (D) ought to be making contact with one of the spark plug leads just as the interrupter points are breaking. See page 296 explaining connections to distributor.

Distributor is usually attached to the magneto—when operated with a magneto, either of the low or high tension type.

The distributor is usually made of hard rubber insulation material with metal segments (see page 268). The rotor with brush revolves by means of a gear wheel twice the size of gear wheel on armature. (fig. 1, page 259.)

Armature for a four cylinder magneto, would revolve at engine crank shaft speed and make 4 sparks during the two revolutions of the crank shaft.

The distributor however would revolve once and make 4 contacts during two revolutions of the crank shaft—hence reason for larger gear on distributor.

On a six cylinder engine the armature revolves 1½ times to one revolution of crank, but distributor is geared to turn one-half the speed of crank shaft, or **one complete** revolution to 2 revolutions of engine crank shaft. (see pages 306, 295 and 294.)

There are two kinds of contact arrangements on a distributor; the "gap-type" as explained on pages 247, 245, 312, and the "brush type" as per fig. 2, page 259.

It must be remembered that while we are referring to the magneto distributor of the true "high tension type magneto"—to show the parts of a "high tension distributor"—the distributor used with the low tension magneto and separate coil (page 260, fig. 3), differs only—in that on a true **high tension magneto**—there are two windings on armature which takes the place of the separate coil.

Low Tension Magneto and High Tension Coil With a Battery to Start on.

The system described in chart 122, fig. 3, which uses a low tension magneto in connection with a high tension coil, interrupter and distributor, would not be satisfactory—for the following reasons:

The magneto is a mechanical source of electric supply. In order to produce electric current, it is necessary to revolve the armature. When the armature revolves, current is generated, but if revolved slowly the current is weak. Therefore it is natural to assume that by merely cranking the engine by hand very little current will be generated. For this reason, a battery is provided to start on, as the source of supply is then **constant**, no matter if engine is cranked slow or fast.

After engine is started, then the switch is placed on the magneto side and the magneto supplies the current to the high tension coil.

This system would then be called a "**dual**" system. Meaning a dual or second ignition system is added, but using the same set of spark plugs.

There are two ways of using a battery to start on, in connection with a low tension magneto; one method would be to have a separate high tension "vibrator" coil, commutator and battery, as per chart 124.

Another method would be to merely add the battery as per chart 123.

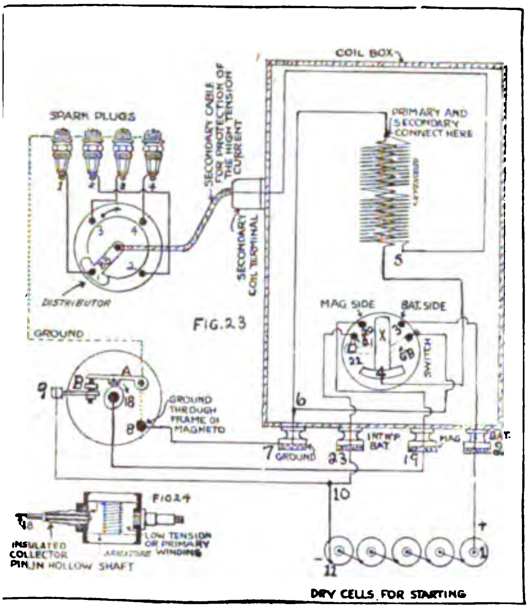
With this latter system, there is but one high tension coil. The only addition to our system first described in fig. 3, chart 122, would merely be a battery.

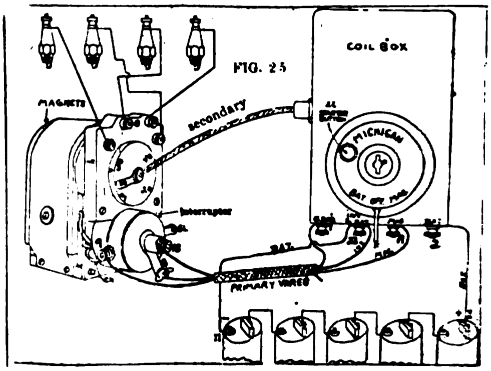
This, of course, would require special connections and be rather complicated, but will be made perfectly clear if reader will refer to chart 123 and study it carefully.

The system described in chart 124, is in reality a true "dual" system, because there are two separate and independent ignition systems, but only one set of spark plugs.

The system shown in chart 123, however, is simpler and was formerly extensively used.

***Note term**—"high tension" distributor—although in this instance it is placed on a "low tension" magneto it is used for the same purpose as used on a high tension magneto—page 268—In both instances to distribute high tension current to the spark plugs.


COIL BOX
SPARK PLUGS
SECONDARY CABLE FOR PROTECTION OF THE HIGH TENSION CURRENT
PRIMARY AND SECONDARY CONNECT HERE
SECONDARY COIL TERMINAL
DISTRIBUTOR
GROUND
FIG.23
MAG SIDE
BAT SIDE
SWITCH
X
GB
22
GROUND THROUGH FRAME OF MAGNETO
A
B
9
18
8
5
6
7
GROUND
23
INTWP BAT
19
MAG
BAT
2
10
11
FIG.24
INSULATED COLLECTOR PIN IN HOLLOW SHAFT
ARMATURE
LOW TENSION OR PRIMARY WINDING
DRY CELLS FOR STARTING



Michigan Low Tension Magneto and High Tension Coil.

The purpose of these illustrations is to show how the interrupter on the magneto can also perform this function for the battery, which has been added to the system. Note that the current from the magneto is connected to contact (19) of the coil box.

We will now briefly outline the path of the current from both sources, and trace them from starting point, all the way through and return, fig. 23.

Battery circuit: When switch blade (X) on coil box is on the battery side, the path of current would be; from the + side of battery, to terminal (2)—then to contact (3) through switch to (4)—then through primary winding (5) to ground connection (6)—thence to ground terminal on coil box (7). From here it leads to wherever the coil is grounded (in the illustration it is shown directly on the magneto, at 8). Now as the interrupter arm (A) is grounded also, it follows that current will flow to it, then through breaker points, then to B, 9, 10 and on to negative terminal (11) of battery.

Magneto circuit: After engine is started the switch is thrown over to magneto side, this cuts out the battery, and current will then be taken from magneto, which is a low tension type.

Beginning at the terminal (18) on magneto, the path leads to terminal (19) on coil box—thence to contact (20-21) through switch (X) to (4) and then follows the same route as the previous current up to ground connection (8). Now since one end of armature coil is grounded, current will flow through it and to starting point.

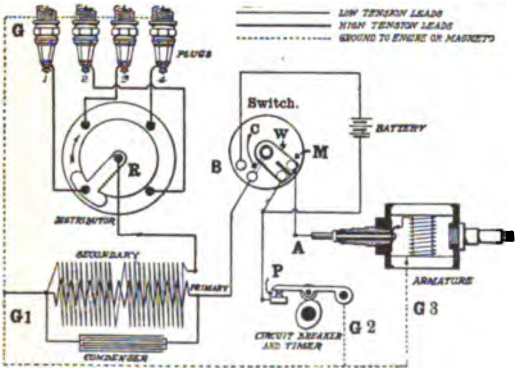
It yet remains to be explained, how the interrupter performs its duty. Notice another contact (21) close to contact (20). Switch lever (X) connects these two contacts and thus opened another path whereby current reaches contact (23) thence through circuit, to (9)—then to contact (B) and breaker points, to (A) whenever the cam is in such position as will allow points to be in contact.

Starting on ignition: Sometimes, the engine can be started by pressing a button on "starter switch" (see fig. 25) a few times in rapid succession. This button is represented in the diagram as (22) and is mounted on a spring tongue, which, when pressed in, makes contact with (GB). **The switch will have to be on battery side of course, and current will be made and broken by the pressing in and releasing the starter button. One of the pistons must be in the right position and ready to fire, and most usually is; about seven out of ten times.** A charge of gas must also be in that cylinder. A charge of gas, or part of a charge will remain in a cylinder quite a long time if rings are tight and precaution taken to draw in a full charge by opening throttle and speeding engine just before it stops.

The high tension circuit from secondary winding of coil is shown in figs. 23, 25. **Condenser, not shown,** is connected around interrupter points per page 274, but is in the coil, per below.

Splitdorf Model D Low Tension Magneto and Coil System.

Splitdorf dual system—using a low tension magneto and high tension coil with battery to start on and magneto to run on: The contact breaker on magneto is utilized for either battery or magneto system. The primary circuit through armature however, must be opened to prevent battery from de-magnetizing the magnets when battery is used.



Magneto circuit: from A to switch blade (W), through connection (C) to primary wire of coil, through ground G1 and G3, to armature. The breaker points (P) it will be noted are connected or shunted across the magneto primary circuit. The circuit proper, is through armature and circuit breaker and the coil primary winding receives only the kick of the armature (extra current) when contact points open. It will be noted battery circuit is open at switch.

Battery circuit: switch blade (W) should now be on B side connecting the two terminals, and magneto terminals on (M) side are open. Current travels from top of battery to switch point, to primary winding of coil, to ground G1 to G2, thence through interrupter points (P) to (lower connection) battery. **Note armature is cut out entirely but not interrupter.**

High tension current is distributed from secondary winding on coil to brush (R) on distributor, thence to spark plug center electrode, thence through spark gap to plug shell ground (G) of engine and frame back to coil where primary and secondary connect.

Condenser, although located in coil, if circuit is traced it will be observed that it "bridges" the points of contact-breaker just the same as on page 274. See page 273 for principle of magneto condenser.

IART NO. 123—A Low Tension Magneto with a High Tension Coil—with the Addition of a Battery to Supply Current to Start with. After engine is started the magneto supplies the current. (Michigan System formerly used on Regal). **Splitdorf Dual System.**

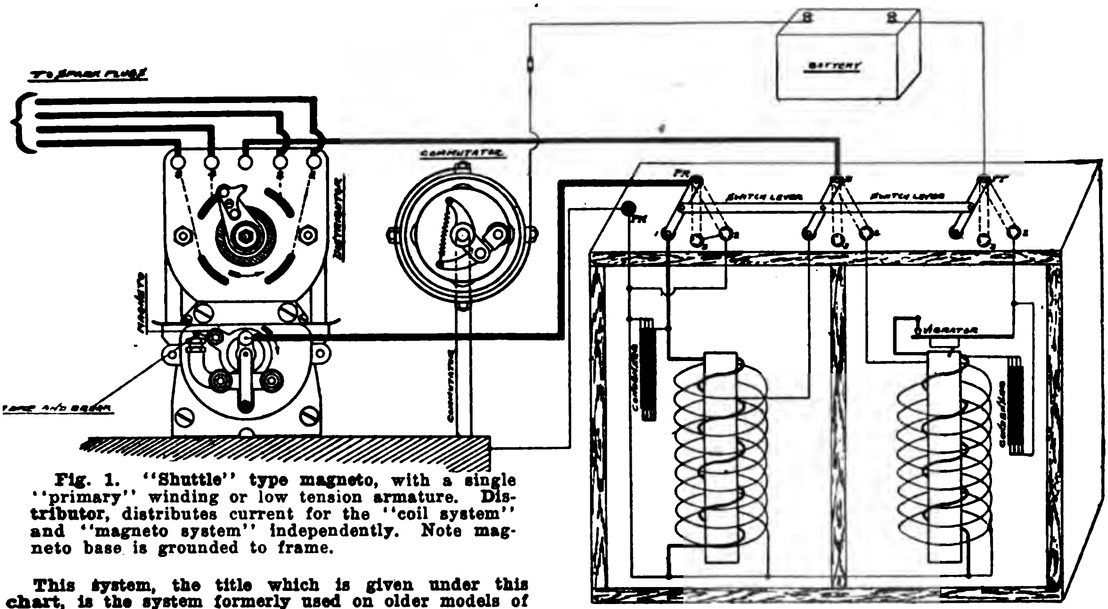


Fig. 1. ''**Shuttle**'' **type magneto,** with a single ''primary'' winding or low tension armature. **Distributor,** distributes current for the ''coil system'' and ''magneto system'' independently. Note magneto base is grounded to frame.

Fig. 2. High tension coil without vibrator, used with the ''magneto system.''

Fig. 3. High tension coil, with vibrator, used with the ''coil and battery'' system. Note the commutator is used with this system, but not with the magneto.

This system, the title which is given under this chart, is the system formerly used on older models of the Packard. Although it is out of date, we show same as an example of how a low tension magneto is used in connection with a high tension coil for one system and a high tension coil and battery is used for the second system, thereby forming a ''dual system of ignition.''

The low tension current from the magneto enters the primary winding of the magneto coil fig. 2, at the post P. R., and leaves it at post P. M., returning to the magneto through the ''ground'' You will readily see what an important part the wire connecting post P. M. with the screw on the rear cylinder has to perform. It is the common path for all of the current of both systems.

The high tension current thus induced in the secondary winding of the magneto coil (fig. 2), follows exactly the same path as described in connection with the high tension battery current from post ''B'' through the distributor arm and plate of the magneto to the respective spark plugs, and back again to the magneto coil through the ''ground'' and post P. M.

Whenever the engine is running, the magneto is developing current. It only passes through the magneto coil, however, when the switch is thrown to magneto side. With the switch in any other position the current is grounded without passing through the primary winding.

The interrupter mechanism of the magneto is located at the end of the armature shaft (lettered ''make and break'') ought to have been lettered ''interrupter,'' as it interrupts the flow of current.

The coil box in the center of the dash contains two coils. Each coil is a complete unit in itself. The right hand coil, fig 3, is for battery current, and is fitted with a single vibrator. The left hand coil is for magneto current, and has no vibrator.

The switch has three positions. Turn to the right for battery, turn to the left for magneto current, and turn to a vertical position for neutral (no current). On the upper side of coil box are four binding posts: P. P. brings low tension current from the battery. P. R. brings low tension current from the magneto. B. transmits high tension current from both systems. P. M. is a common ground wire for both kinds of current from both systems.

The low tension current from both the battery and magneto, though of good amperage (volume), is low in voltage (pressure). The two coils receive from the battery r magneto their respective low tension currents and deliver currents of high tension.

The battery and coil system: is used for starting the engine, and for reserve. There is a storage battery, which also provides a low tension ''direct'' current. The battery current passes through the battery coil, fig. 3, and the contact for this battery and coil is made by a ''commutator,'' operated from the cam shaft. This practically makes two systems of ignition using but one set of spark plugs; therefore, it is called a ''dual'' system ignition.

The battery and coil primary current; starts at the positive pole of the battery, the current follows the connecting wire to the post on the coil marked P. P. At this point it enters and passes through the primary winding of the battery vibrator coil, fig. 3, coming out again at post marked P. M. and along the connecting wire to the ground connection on engine frame. The only path by which it can return to the battery is through the contact shaft, and roller to one of the binding posts, and by means of the metal connecting strap to the wire running to the negative terminal, the circuit being complete at each time the roller in the contact box passes over one of the metal contact pieces.

The high tension current: Whenever this low tension circuit from the battery is completed, as above described, a high tension circuit is induced in the secondary winding of the battery coil. The high tension current leaves the coil at post ''B'' to the central post at the top of the distributing plate on the magneto, thence to the distributor brush, which revolves to the left (see fig. 1).

The current then travels through the **distributor** brush to segments, thence to spark plug connected with segment on which the distributor brush makes contact. The secondary current returns from metal shell of spark plug to ''ground'' and back again through engine frame to post P. M., thence to the battery coil, fig. 3.

The battery current is generated by chemical action, and is ready to flow the instant the circuit is completed. It is, therefore, particularly useful for ''starting on.'' It is only necessary to break the circuit to stop the flow of the current.

The vibrator operates only when the low tension current is passing through the primary winding of the battery coil.

Condenser in coil fig. 2, protects interrupter points of magneto and in fig. 3, protects coil vibrator points, or both.

CHART NO. 124—Example of a ''Dual'' Ignition System; employing a ''vibrator'' coil with batter to start on and coil ''without vibrator'' and low tension ''magneto'' to run on. The on distributor on magneto distributes the high tension current to the spark plugs.

Note—chart 125 omitted (error in numbering).

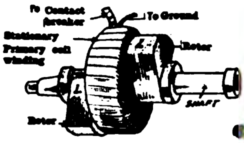
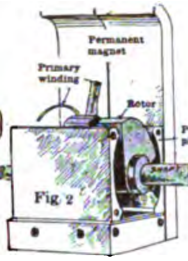


Fig. 1 Inductor Type of Armature.



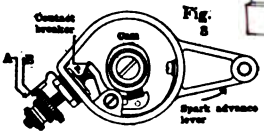


Fig. 3

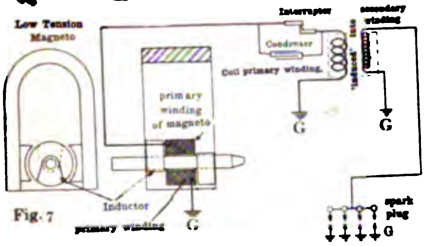


Illustration showing how a high tension coil is used in connection with Remy low tension magneto. (G—ground.)

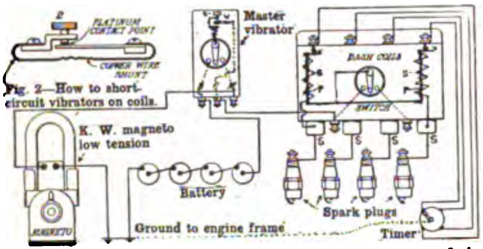


Fig. 4: The K. W. low-tension magneto used in connection with a master-vibrator coil.

The Remy Low-Tension Inductor Type Magneto (Model R L).

The principle is similar to the K. W. fig. 8, page 256, except the Remy rotor is a half-rotor, whereas the K. W., both ends of rotor are utilized. The Remy produces 2 impulses per rev. and the K. W. 4 per rev.

Fig. 1: Remy rotors (L) which revolve and the stationary single primary winding.

Fig. 2: Remy inductor or rotor in maximum position, similar position as fig. 8B, page 256.

Fig. 3: Remy contact-breaker. The points (P) should have a clean surface. Dirt and grease should not be allowed to accumulate.

If engine misses with spark retarded at slow speed, adjust the contact screw (B) out a few notches.

If engine misses with spark advanced at high speed, adjust the contact screw in a few notches.

On all magneto ignition systems adjust spark plug points not over .025" or 1/40th of an inch apart.

The contact-breaker is used on this magneto just the same as on a shuttle type magneto armature; to interrupt the flow of current in the primary winding.

To time the armature, place rotors just the same as a shuttle type armature.

The K. W. Low-Tension Inductor Type Magneto and Master-Vibrator.

Fig. 4: The K. W. inductor type of low **tension magneto,** used with a master-vibrator. Dry cells as a source of supply for starting when switch lever is on the left, or (B) side. Magneto is used when switch is on (M) side. See page 230 for "master-vibrator." Also page 256, fig. 8, for inductor type of armature used on this magneto. Note the vibrators on dash coil are short circuited, per fig. 2, and are not used on the multiple dash coil to the right, as the one vibrator on the master-vibrator coil does the vibrating for the 4 coils—see pages 230 and 285.

The Oscillating Type Magneto.

Figs. 1 & 2: This type is a regular shuttle or armature type magneto and is the original magneto principle, designed for slow speed engines. The **armature** does not revolve but **oscillates** back-and-forth from **position** 1, to 2 (30°).

It can be used with an igniter arangement, fig. 1, which is similar to fig. 1, page 260—except the igniter rod is actuated by lever (L) on magneto, which is tripped by trip (J). **It can also be used with a magnetic plug** as shown in fig. 2.

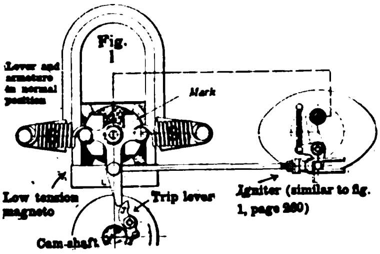


Fig. 1
Lever and armature in normal position
Mark
Low tension magneto
Trip lever
Igniter (similar to fig. 1, page 260)
Cam-shaft

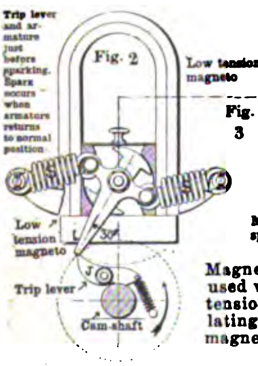

Trip lever and armature just before sparking. Spark occurs when armature returns to normal position
Fig. 2
Low tension magneto
Low tension magneto
L
30°
J
Trip lever
Cam-shaft

Fig. 3

Magnetic spark-plug

Magnetic plug used with low-tension oscillating type magneto.

The Magnetic Plug.

Fig. 5: The principal parts of the magnetic plug are, magnetic coil 5, pole-piece 2, interrupter 20 and contact piece on plug shell 21. Plug is screwed into cylinder. **Principle;** owing to sudden flow of current through coil (5), the upper portion of hammer bar (1), called the armature, is attracted to pole-piece (2), which effects a quick separation of contacts 20 and 21 producing a spark at these points.

Fig. 4: Illustrates how the magnetic plug is used in connection with a low-tension magneto (type "K4" Bosch) with a revolving armature, with a main and auxiliary winding, one being a continuation of the other, and a distributor for connections to the magneto plugs. This system is termed the Honold system and is for 2, 3, 4, 6 and 8 cylinder engines.

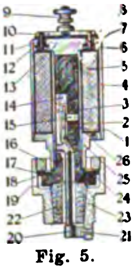


Fig. 5.

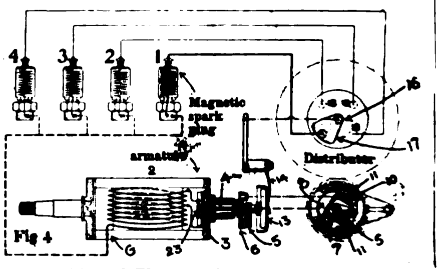


Fig 4

CHART NO. 126—Inductor Type of Low Tension Magnetos; one giving two impulses per **revolution,** the other (fig. 4) giving four impulses per revolution. **The Oscillating Type Magneto. Magnetic Plug.** See page 924 for Remy magneto circuits.

*Note—Charts 125, 127 and 128 omitted (error in numbering).

*Low Tension Magneto with "Inductor" Type of Armature.

In the foregoing matter we have dealt entirely with the low tension magneto using a "**shuttle**" type of armature with its primary winding, all of which revolves between the magnet poles.

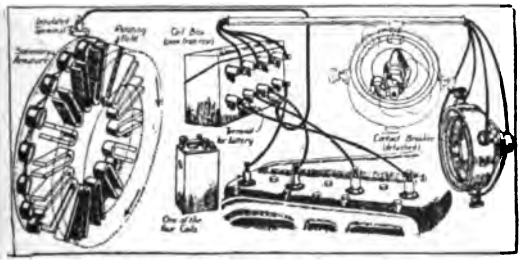
There is another type of armature called the "inductor" type. This armature differs, in that the primary winding, fig. 1, chart 126, remains stationary, whereas, the inductors (L) revolve; principle is explained in chart. This type of armature generates "alternating" current of low tension, and must be connected with an interrupter, when used with a coil. In fact, the same principle is used as with the shuttle type armature. It gives **two impulses per revolution.** The voltage is of low tension or about 6 volts.

Another type of "inductor" armature to that shown in fig. 1, chart 126, is used in the K. W. low tension magnetos. This armature is illustrated in fig. 8, page 256. Note the inductors are similar to the Remy shown in fig. 1, chart 126—except the K. W. uses both ends of rotors, whereas Remy one end, but rotors 180° apart. Instead of the inductors or rotors on the K. W. being placed so that two impulses are given per revolution; note the position and method the inductors are arranged. With this arrangement, the inducter cheek would break from the pole of magnets every quarter revolution. Therefore, there would be four positions when the current would read maximum, or **four impulses or sparks per revolution** (figs. 9 and 10, page 256). The voltage of primary winding is about 6 or 8 volts.

This type of magneto is shown connected to a "master vibrator coil" system as per fig. 4, chart 126. The speed of this armature is about 3,000 revolutions per minute. It is **not geared at a fixed speed** as the shuttle type armature, but because it gives twice the number of impulses per revolution, and by running it at a very high rate of speed, generates an alternating current, the changes taking place so rapidly, it is almost continuous. ‡This is **one type of alternating current generator which would light lamps** and operate with a vibrator coil, but it would not recharge a storage battery. A storage battery can only be charged with a true continuous or "direct" current.

‡The Ford Magneto—an "Inductor" Type.

Another form of a low tension magneto with an "inductor" type armature is the Ford magneto. The Ford magneto generates a low voltage also, of about 6 volts or slightly more, owing to the speed.** The current generated is "alternating."



This is also called an inductor type of armature because the coils of wire called the "stationary armature," remain stationary and the inductors or magnets called the "rotating field" revolve.

Instead of there being two impulses per revolution, there are **sixteen impulses per revolution,** because there are sixteen coils and sixteen inductors or magnets.

In other words, each revolution of the fly wheel, to which the magnets are attached, means one revolution of the crank shaft. **There are 16 positions of the magneto when the current output is at its maximum height** and each of these positions is called the peak of the current wave. **There are, also, 16 positions during which no current is flowing at all.** Each of these is called the neutral position and each is half way between two peaks. Therefore, every sixteenth of a revolution of the magneto a position is reached when no current is being generated and are termed "dead points."

Each alternate peak is of an opposite polarity; that is, there are 8 positions in each revolution when the current flowing from the magneto winding to the spark coil is **positive** and between these positions are 8 other positions when the current is **negative.**

Relation of the Low Tension and High Tension Magneto.

We have now dealt with practically all of the low tension types of magnetos in general use. The true form of low tension magneto from which we will produce a high tension magneto, is the type using the "shuttle" armature which revolves between horse shoe type, permanent magnets.

The high tension magneto which will be treated in instruction No. 22, is merely a modiification of the above mentioned "shuttle" type armature magneto.

---

*Note—These systems are now seldom used for automobile work, but are shown in order to give the reader the information and to bring out the less understood points.

See the Ford Supplement pages 805 and 770. for "relation of speed of Ford magneto to voltage generated." ‡The Ford inductor type magneto will light lamps** and supply current for a vibrator type coil, but voltage varies considerably. The Ford magneto will not charge a storage battery, because the current generated is alternating. A rectifier is shown on page 809, which could be used with a Ford magneto.

Magneto Principle of Operation.

As previously stated a low tension magneto can supply current for a separate high tension coil, or a low tension "make and break" ignition system.*

The low tension magneto has but one winding on the armature called the primary winding. A high tension magneto has two windings on the armature, a primary and a secondary winding, therefore when it is used, the high tension coil is dispensed with entirely. The high tension magneto is treated in the next instruction. Our explanation here, of magneto principle will be confined to the low tension magneto.

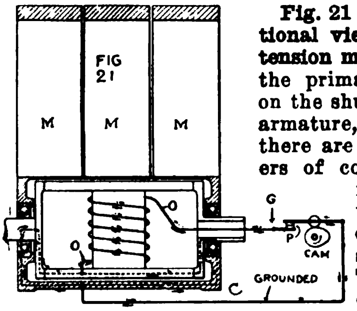


Fig. 21 shows a sectional view of a low tension magento, O is the primary winding on the shuttle type of armature, of which there are several layers of coarse copper insulated wire (only one layer shown). This wire connects with a contact-breaker P and G. This contact-breaker would be in the form of an igniter (M) per page 260, fig. 1 and **inside** of the cylinder—if of the "make and break" system and a true low tension ignition system and part of the circuit would be grounded.

If system consisted of a low tension magneto and high tension coil, per fig. 3, page 260, then the contact-breaker G & P above would be mounted on **end of armature shaft** and the circuit would be opened at the correct time, producing a spark, by a cam on end of armature shaft. The two circuits of above systems can be traced on page 268.

The circuit of a magneto system is a closed circuit, that is, the primary winding is closed and the circuit opened by the cam only at the correct time, which is just as the armature passes vertical position, at which time the greatest energy exists in the circuit, called **maximum** position.

With magneto ignition, current is generated and stored in the winding during the time it is closed. When this storage limit has been reached the interrupter opens the closed circuit and the stored energy is transmitted to igniter points or primary of high tension coil—in a similar manner as the holding a water hose closed and releasing it suddenly—the pressure is greatest just as it is opened.

In other words the spark is produced by the change from closed circuit to open circuit when the contact-breaker is opened by the cam. This break is made very quick and in order to get the hottest spark at the points of spark plugs or igniter, the opening should occur when armature is in maximum position. If the opening occurs earlier or later than maximum, then the intensity of spark is weaker (see page 309).

The correct time for the contact points to separate and open the circuit and produce the hottest spark, is when armature is **just passing** vertical position, or armature cheek or face has just broken away from the pole tips, as shown in e, fig. 7, page 267.

If you turn an armature by hand in direction of rotation, you would find that there is a very strong magnetic pull to armature just as the armature cheek breaks from the pole tip, or about 1/16 in., which at this instant, the contact points (P) should separate and at this time the spark is at its best or maximum strength—(see foot note bottom page 309).

Impulses.

****With the average shuttle type armature magneto the maximum position is reached twice during one revolution of armature,** which times are called **†impulses.**

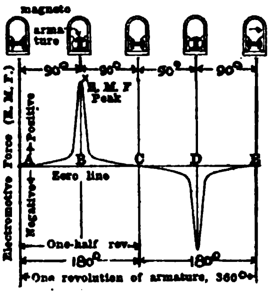


Fig. 20 Voltage Wave

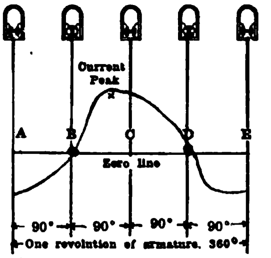


Fig. 30 Current Wave

For example, referring to fig. 20, note armature is in a horizontal position and the ‡E. M. F. (electro-motive-force) is at zero. When armature travels 90° or ¼ turn in direction of rotation, it is in a vertical position and technically this is the maximum position and where contact-breaker points should separate. Note the E. M. F. has reached its highest peak.

But owing to the fact that the circuit is a closed circuit in which current is flowing, the inductance of the coil and the armature reaction of coil combined produce a hindering effect that produces a more even change of flux and makes maximum position of armature occur a few degrees later.

The illustration fig. 20, shows the open circuit voltage wave under ideal conditions, whereas the current wave fig. 30, would be broad and flat, which allows for more **sparking range. The beginning of this sparking range** comes **after** the armature cheek separates from the tips of the pole pieces, therefore is strongest just as the armature cheek breaks from the pole tips.

Note voltage polarity changes at A and C, fig. 20, whereas the current polarity changes at B and D, fig. 30.

Two Sparks Per Revolution.

Alternating current is produced because, during each revolution of armature 360°, there is generated and stored in the primary winding of the armature two electrical impulses in **opposite** directions.

For instance, from horizontal position (fig. 20), to horizontal position again, armature has turned ½ revolution or 180°—the voltage (e. m. f.) polarity is in a **positive** direction. During the next 180° or ½ rev. it is in a **negative** direction. Therefore during one revolution of 360° the direction is changed twice and two maximum sparks can be produced.

---

*It would appear as if the "make and break" system would be the simplest, which it is, but movable contact points in cylinders exposed to intensity of the heat soon gets out of adjustment.

**On some magnetos for 8 & 12 cylinder aero engines the pole pieces are arranged so that 4 maximum positions are reached per revolution—see page 922. The K. W. magneto, page 256 also produces 4 maximum positions or sparks per revolution. ‡Refers to voltage, see page 207.

†The word impulse is also used in connection with the ignition of gas in cylinder; for instance, when the explosion takes place in cylinder the piston receives an "impulse."

The cam: As the change takes place twice during one revolution of the armature it is necessary that a two point cam be used on the **contact-breaker** in order to break the contact twice durone revolution—see pages 257, 259 and 261.

To set the magneto: As stated, the point at which the armature cheek is just breaking from the pole is the **correct position to set the magneto armature**—and at the same time the **interrupter points should just separate**—both operations should occur at the same instant. (see page 309.)

Advancing and retarding: These cams made of steel are in a casing, and by having this casing made so that it can be moved through say, the one-tenth part of a circle—the time of the interruption of current can be advanced or retarded with relation to movement of armature. This means the **spark will occur early or late,** relative to movement of pistons. (see page 309.)

How Current is Produced.

A permanent magnet is made of hard steel and retains its magnetism* Its magnetic influence extends from one pole to the other, which is called the magnetic field as shown in fig. 2.

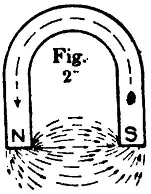


Fig. 2

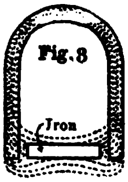


Fig. 8

The magnetic lines of force always flow N into S pole. If a bar of iron be placed between the poles (N&S), or in the magnetic field, fig. 8, the magnetic lines of force will travel freely through the iron, it will be an easier path, because the air gap between poles offer 280 times the resistance as does iron. The magnetic lines will also be greatly increased.

Therefore a soft iron armature core, curved, so it will revolve freely but as close as possible to the pole pieces (soft iron also), is placed between the pole pieces of the permanent magnets. A coil of insulated copper wire is then wound on the H section of armature core—see fig. 4.

Cutting Lines of Force.

If a piece of copper wire in the form of a closed loop, is moved **down** quickly past the pole of a magnet, it will cut the lines of force down and a momentary current is **generated** in the wire, flowing say, from T to S, and if connected to a galvanometer (G), needle will be deflected to one side, from zero.

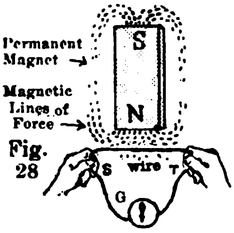


Fig. 28

If wire is moved **up,** cuting lines of force up, another momentary current will be generated in the wire but in an opposite direction, from S to T, and needle will be deflected to the opposite side of zero.

The momentary induced current is greatest when wire is moved so as to cut the magnetic lines of force at right angles—applying this principle to the coil of wire on magneto, the coil would be cutting the greatest number of lines of force when in position 6 to 7—or when it is moving at right angles to the lines of force.

The electric current in the wire depends upon the E. M. F. (electro-motive-force) causing it to flow—therefore E. M. F. is generated in wire when it is made to cut the lines of force, and a current flows when it is complete, due to the generated E. M. F. The faster the coil cuts the lines —greater will be the E. M. F. generated.

The generated E. M. F. also depends upon the strength or quantity of magnetic lines of force; the speed or rate of lines cut per second; the number of wires cutting the lines—therefore several layers of wire are used on the armature.

Referring to fig. 4, the coil is not cutting any of the lines of force—the lines are passing freely through armature core from N to S—therefore e. m. f. (voltage) strength is at zero.

Fig. 5: The L side of coil is starting to cut the lines of force up, and right side of coil (R) is cutting down—E. M. F. is gradually increasing in coil. Lines flowing down through core N to S.

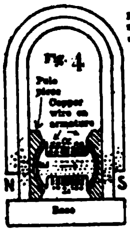


Fig. 4

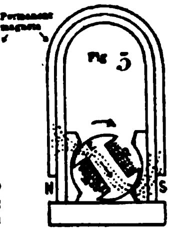


Fig 5

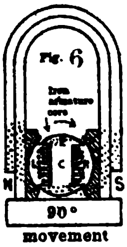


Fig. 6

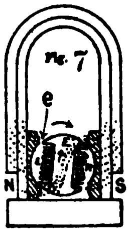


Fig. 7

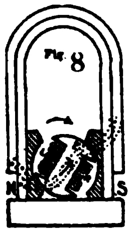


Fig. 8

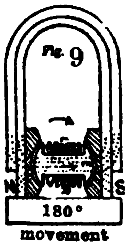


Fig. 9

Figs. 6, 7: In this position the coil is cutting the greatest number of lines at right angles—the lines have followed an easier path and are passing through the ends of armature core—none through center or through coil—the generation of energy has reached its maximum and is stored in the wire—the actual †flux in the core is now at zero. The thing that is most important is, not the amount of flux that is flowing through the coil at any instant that is of importance to the generation of current, but rate at which this flux is made to pass from one path to the other as it changes from out of coil into it again. Therefore from position 6, when all flux is out of core or center of coil, to position 7, when the flux starts to pass through core or coil in an opposite direction (fig. 7) represents the greatest rate of change and is the time for the contact points to open, at which time, is the practical maximum position.

Fig. 8; the lines of force (flux) are now passing through armature in a reverse direction to what it did in fig. 5, but voltage polarity is still same direction, because the L & R side of coil is still cutting lines of force in the same direction—but as coil is cutting a less number of lines, the e. m. f. weakens as it travels to zero position again.

Fig. 9: Armature has turned ½ revolution. No lines are being cut, voltage (e. m. f.) strength is at zero, but current still exists without generation—due to the storage capabilities of the armature windings. For instance, if we consider the magneto as a sort of pump and reservoir on **short circuit,** we can see why the reservoir can be full even though the pump has stopped.

The reader must bear in mind that there are two phenomena in connection with the magneto; one is the voltage peak or maximum voltage fig. 20, and the other is the current peak or maximum current fig. 30. These two peaks are not in unison. The current peak lags behind the voltage peak as much as 90°, when armature gets up to speed. This is the reason why there is a strong current flow even though the voltage wave is at zero. As armature moves from position fig. 9, the same cutting proceeds as before, but as the R and L side of coil will now cut lines in an opposite direction, the voltage polarity will be in opposite direction for the next half revolution.

***A permanent magnet will retain its magnetism a long time if a keeper is kept on ends of poles**—see page 303. The armature on a magneto, when in a horizontal position acts as a keeper—see page 302. **An electro magnet** is a magnet consisting of an iron core around which is wrapped wire. When direct current is passed through wire the **iron core** becomes a magnet—if flowing in one direction. Soft iron cores are used, as it quickly loses its **magnetism** when current ceases flowing.

†**Magnetic flux** is the total number of lines of force flowing through a magnetic circuit.

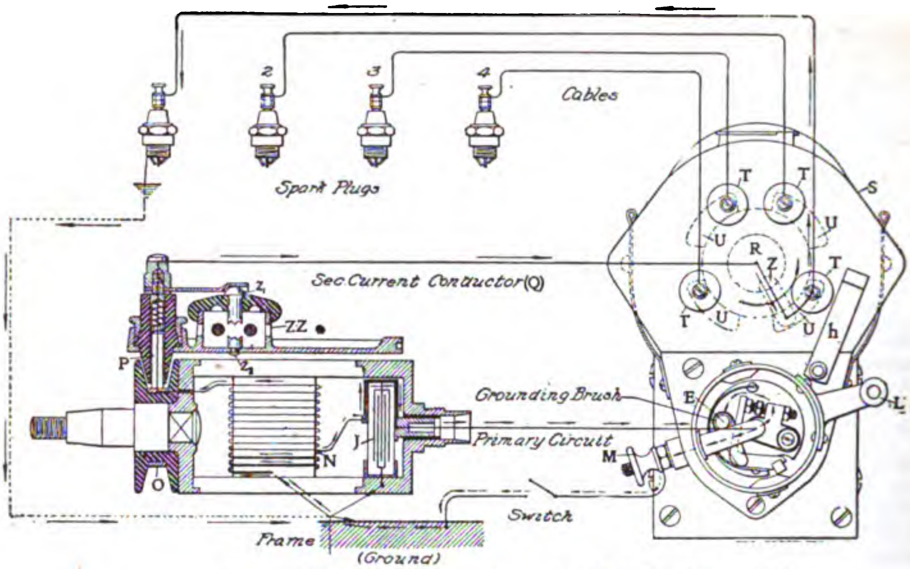


Fig. 1—Diagram of Connections of a High Tension Magneto.

Names of Principal Parts.

SW—Secondary winding of wire over the PW primary winding.

O—Collector ring. P—Brush carrying high tension current to the base of distributer (R).

The current is then distributed to the four plugs through distributer arm, (Z) to the terminals (T).

ZZ—is the spark gap. J—Condenser. S—is insulated base of distributer.

See Chart 130 for other parts, cross section of which can be seen in Fig. 2, this Chart.

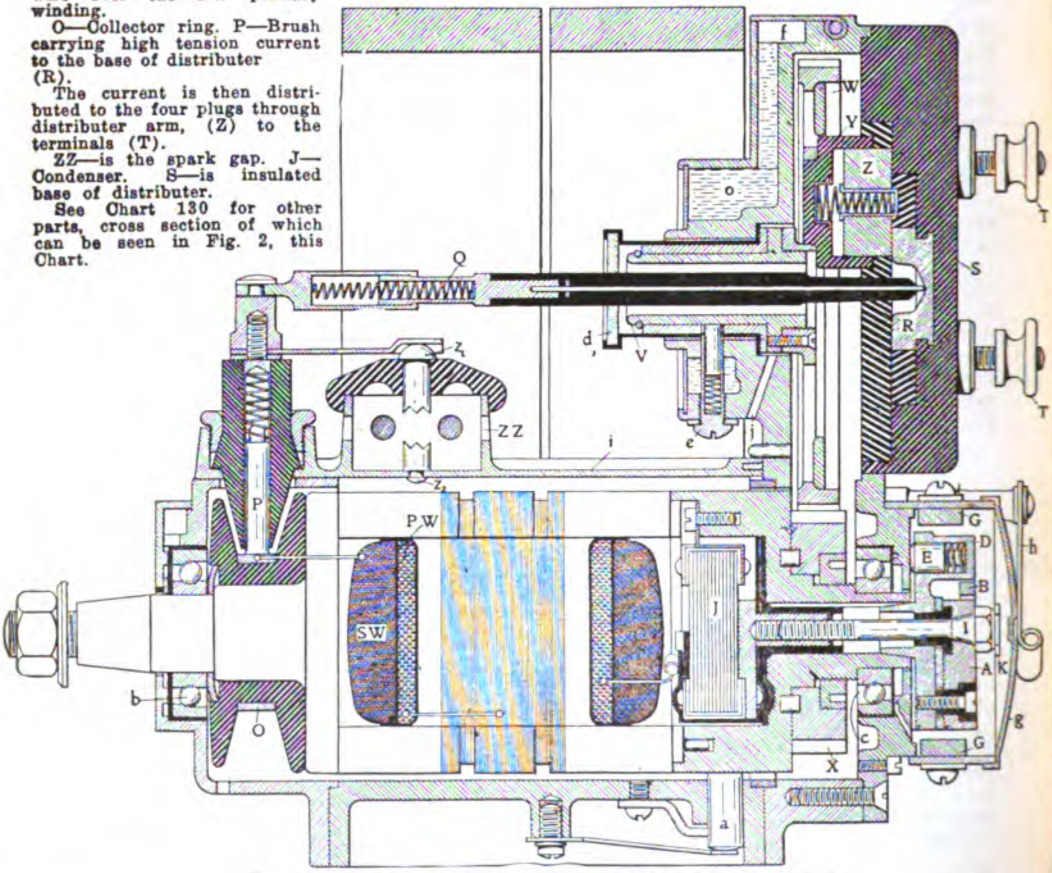


Fig. 2—Longitudinal Section Through High Tension Magneto.

CHART NO. 129—Primary and Secondary Circuit of a High Tension Magneto. Armature is known as a compound type, meaning double wound. It revolves with its wire winding.

ote—The distributor brush (Z) is revolved by a gear (W) which is revolved by a gear (X) on armature. ype DU4 Bosch.)

arts 127 and 128 omitted (error in numbering).

INSTRUCTION No. 22.

THE HIGH TENSION MAGNETO. Description; Construction, Parts. Combinations of Dual and Double Systems. Wiring Diagrams. Leading Magnetos. Four Ignition Systems on one Engine.

Preliminary Description.

The high tension magneto is not only a mechanical generator or a substitute for the battery, but combines all the elements of a complete ignition system, except the plugs and switch.

It performs three separate essential functions as follows; generating current; transforming the current to a high pressure; distributing the high tension current to the individual cylinders. Besides these main functions, a number of minor functions have to be performed. The high tension magneto differs from the low tension magneto in only a few particulars.

Armature winding: The armature on the high tension magneto is wound with an additional winding, called the "secondary winding," whereas the low tension magneto has but one winding called the primary winding.

Instead of using a "separate" high tension coil, this second winding on the armature of the high tension magneto takes its place. (See figs. 1 and 2, chart 129.) This secondary winding is carefully insulated from the primary winding, except at one end, where both it and the primary winding are grounded. (P W) is the primary winding, and (S W) is the secondary winding (fig. 2). One end of (S W) is led, carefully insulated, to a collector ring (O) mounted on the armature shaft, and a corbon pencil or brush (P) rubbing on this collector ring takes off the secondary current and leads it to distributor brush (Z).

The other respect in which this type differs from the low tension magneto in that the condenser which is employed in connection with the interrupter is usually built into the high tension magneto (J fig. 2) whereas with the low tension magneto, the condenser is in the separate high tension coil. The condenser is usually, though not necessarily located on the armature shaft in order to get it as close to the interrupter as possible, and it is there shown in fig. 1, chart 129 (J). In some magnetos, for the sake of greater accessibility and other reasons, the condenser is located outside the armature in a stationary sealed box.

The purpose of a condenser in explained in chart 109.

Owing to the fact that the secondary coil of the high tension magneto is located on the armature itself it follows that it not only receives an induced current, due to the breakage of the primary current, but itself induces a current like that of the primary coil, but smaller in volume.

It has the same form of armature, field magnets and principle of interrupter as the low tension magneto, but varied construction. The armature-coil, however, is different, having a primary winding with a secondary winding over it.

*Construction.

The high tension collector ring (O) performs for the high tension current the same function that the spring (S) at the end of the armature shaft in fig. 5, page 258, does for a low tension current. That is, in this instance, it conducts the high tension current from armature to the distributor.

The collector ring is hard rubber with a brass ferrule (O) surrounding it, against which ferrule a heavily insulated stationary carbon pencil (P) bears. The hard rubber spool has wide flanges for the purpose of preventing the high tension current from escaping, by giving it a long path to travel from the brass contact ring to the shaft. As hard rubber is much more resistant than air, the current tends to travel over the surface of the spool instead of striking through it.

****The distributor:** It has already been explained how the high tension current is induced in the secondary or fine wire winding of the armature at the moment the current ceases in the primary winding. It remains to explain how this high tension current is distributed to the four spark plugs of a four cylinder engine in succession.

The beginning of the secondary winding (S W) (figs. 1 and 2, chart 129) is connected to the end of the primary winding at (N), and since one end of the primary winding is grounded, the secondary is also grounded through the primary. The end of the secondary winding leads to an insulated contact ring (O), fig. 2, at the driving end of the magneto.

From this ring the current is taken off by a carbon contact brush (P). From the brush

---

*For example of a high tension magneto, the Bosch, type DU4 as shown in charts 129 and 130 is used.

****This type of distributor is the "brush" type,** as it makes a wiping contact. The "gap-type" is shown in the Berling, page 312, and explained on page 247.

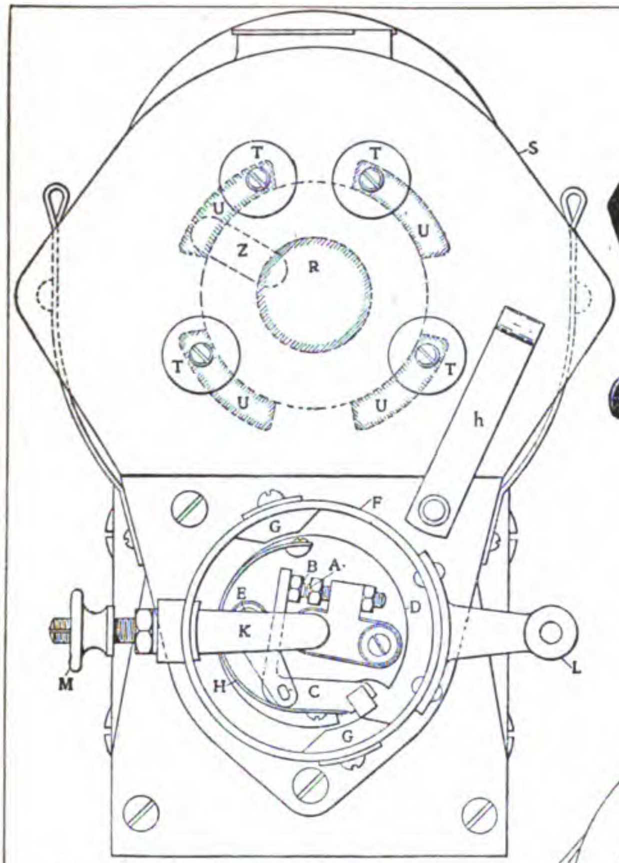


Fig. 2—Front View of the Magneto Showing Details of the Circuit Breaker and Distributor.

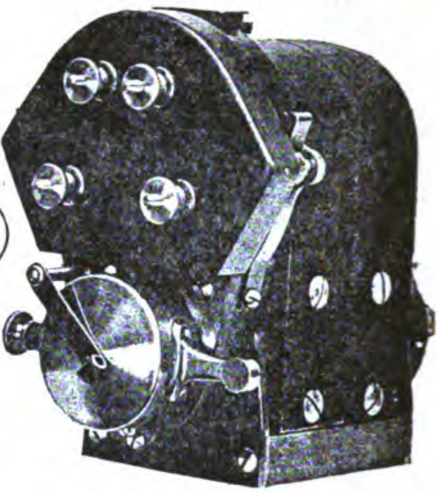


Fig. 1—A Bosch DU-4 Type of High Tension Magneto. Cover is over the Distributor and Breaker Box.

Distributor Parts.

T—Terminals to spark plugs.
Z—Brush.
U—Segments connected with terminals on which brush slides.
R—Connects with brush P through Q in Fig. 2, Chart 129.

Interrupter Parts.

A—Platinum point on contact breaker.
B—Platinum points on interrupter arm.
h—Spring for holding cover in place.
G—Cams which raise C.
H—Spring which holds A and B in place.
F—Outer shell of housing which is shifted for advance or retard, by movement of lever (L).
K—See fig. 2, chart 129.
E—See fig. 2, chart 129.

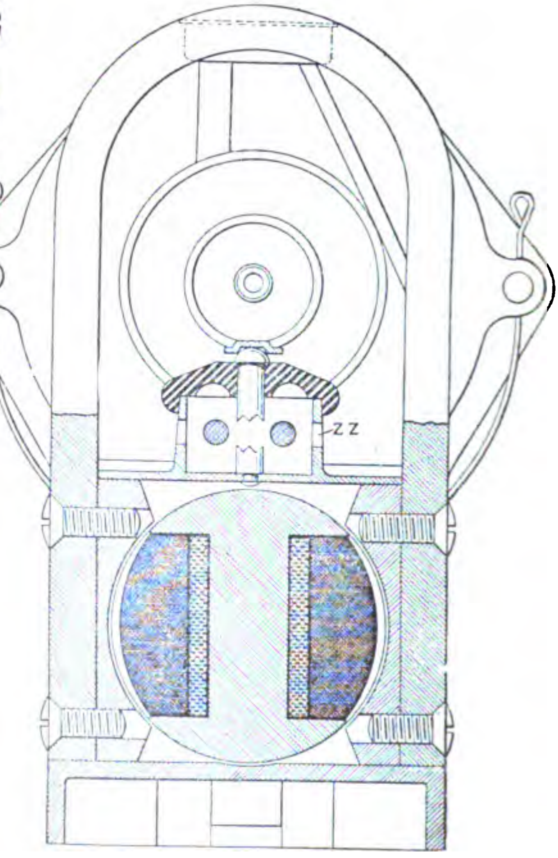


Fig. 3—Cross Sectional View of Magneto. ZZ—Spark gap. Note the pole pieces screwed to end of field magnets. The dark shaped part on armature represents secondary winding; the light shading, primary winding.

CHART NO. 130—Names and Location of Parts of a High Tension Magneto. (Bosch.)

M—is ground terminal. A wire is led from this terminal to a switch which must be open when magneto is in operation (see fig. 1, page 268).

holder the current is carried through a spring contact conductor (Q) to the central distributor contact (R).

The distributor consists of a disc of insulating material (S), in which are imbedded on the inner side one central cylindrical contact-piece (R) and four annular sector-shaped contact pieces (U U U U, fig. 1, chart 129).

The distributor also comprises a shaft (V, fig. 2), which carries a gear wheel (W) meshing with a pinion (X) on the armature shaft. The gear wheel (W) has twice the number of teeth as the pinion, and the distributor shaft (V) therefore makes one turn while the armature makes two.

Distributor speed: The reason for driving the distributor at one-half the armature speed is as follows: The armature as already stated, turns at the speed of the engine crank shaft. The magneto here described is for a four cylinder, four cycle engine. In such an engine each cylinder requires a spark once in two revolutions of the crank shaft.

The distributor is therefore geared so that it makes one revolution to two revolutions of the crank shaft and establishes connection between the high tension or secondary winding of the armature and the spark plug to each cylinder once in every two revolutions of the crank shaft.

The gear wheel (W) carries a brush holder (Y) containing a carbon brush (Z), which is adapted to make contact simultaneously with the central distributor contact (R), and with one of the annular distributor contacts (U).**

The distributor sectors (U) **are surrounded** at the inside and outside by annular rings of a highly insulating material, since they carry the high tension current.

Each of the four annular contact segments (U) has secured to it a binding post (T) on the face of the distributor disc, and each of these binding posts is connected by a high tension (highly insulated) cable to one of the spark plugs.

There are numerous methods of taking the current from the secondary winding on the armature, but in the Bosch a carbon brush pressing on an insulated ring is adopted, thus allowing the armature to rotate freely, and also enabling the induced current to be drawn off.

The distributor is, in effect, a rotary switch, especially insulated and provided with a number of contacts equivalent to the number of cylinders on the engine.

Magnets and pole pieces: In any standard magneto made on this principle the general construction would be as follows: The field magnets consist of two—or usually three—pairs. One magnet of each pair being superimposed above the others. (See fig. 3, chart 131.)

In some few cases three magnets are placed one over the other. The magnets are set to give correct north and south polarity. All north poles on one side and all south poles on the other side.

The ends or poles embrace "pole pieces" of soft iron bored out to allow the armature to rotate quite freely, but very closely to the pole faces; in some cases the clearance is only .002 inch.

The armature: Consists of an armature core of soft iron of H-shaped cross section; also referred to as a shuttle armature. This core of soft iron serves to form a bridge for the magnetic flux between the pole shoes, and also to carry the winding in which the current is induced.

The armature is, in practically every standard type of the well-known "shuttle" type. The best class machines have the armature built up of thin stampings of soft iron, each insulated from the other by a thin film of varnish. This form of construction is known as a "laminated armature core." A laminated armature core is shown in fig. 6, chart 121, and a complete armature wound with double winding is shown in fig. 1, chart 131. It has the advantage over a solid cast-iron core in that the electrical efficiency is higher through the absence of "eddy" currents in the iron core which represent considerable waste of energy and cause heating.

By breaking up the core into thin sections, the currents cannot circulate through the iron, (spoken of as "eddy currents.") In the case of a solid core, the iron would be annealed to render it as "soft" as possible, to obtain the best magnetic effect.

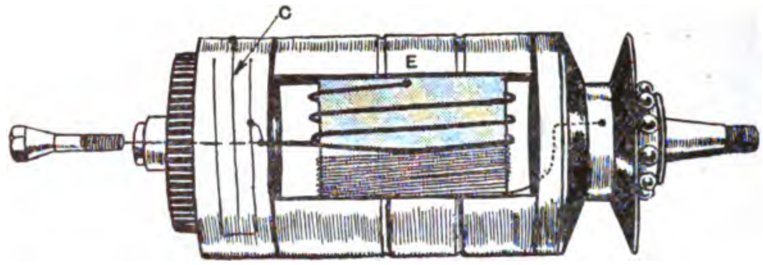
Armature winding: The armature core is first insulated with mica or similar material. Then it has several layers of heavy insulated wire wound upon it. To the end of this heavy wire is connected the beginning of a very fine wire (No. 36 or 40)* insulated with silk, which is wound on the core until the slot is filled almost to the height of the cylindrical portion, after which a wrapping of insulating cloth is applied, and bands are put around the circumference of the armature to prevent the wire and insulating material from flying out and coming in contact with the pole shoes when the armature is rotated at high speed. To the ends of the armature the steel shaft or spindle is fixed by brass end plates. (See fig. 6, chart 121.)

It will thus be noted that there are really two windings on the armature whereas the low tension magneto has but one winding —an inner winding of relatively few turns of heavy wire, and an outer winding of a large number of turns of fine wire.

---

*The winding of a Bosch DU-4 magneto usually consists of 8 layers of No. 21 insulated primary wire and 70 to 72 layers of No. 36 silk covered secondary wire.

**See foot note bottom of page 269.



ARMATURE OF A MAGNETO.

Fig. 1.—A View of a Double Wound High Tension Compound Armature. The Armature is just the same as used in a Low Tension magneto with the exception of there being another winding of fine wire over the primary winding.

One end shows the gear which drives the distributor gear. The other shows the "collector ring" and drive end. Note (E) is where one end of the primary wire is grounded. The other end of the primary winding connects with condenser, then to screw (see I, Fig. 2, Chart 129). One end of secondary connects to collector ring. The other end connects to primary. C—is the condenser.

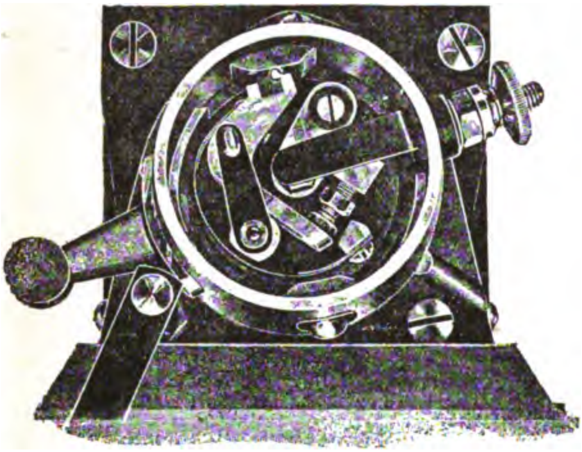


Fig. 2—Photographic View of the Circuit Breaker or Interrupter, on the opposite end to collector ring. Same type as shown in Fig. 2, Chart 130.

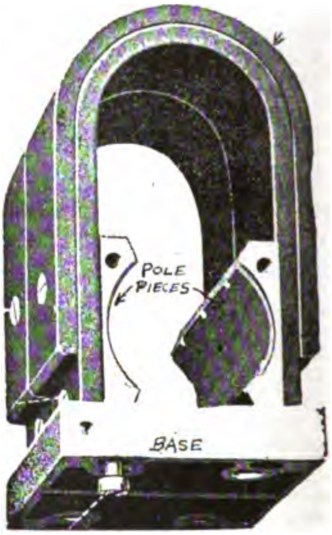


Fig. 3—The Horse Shoe Magnets, Pole Pieces, etc. are the same principle as used on a Low Tension Magneto.

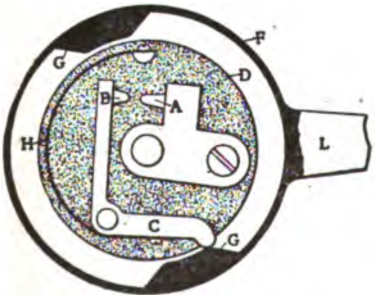


Fig. 4—Circuit Open on Interrupter. See text for explanation.

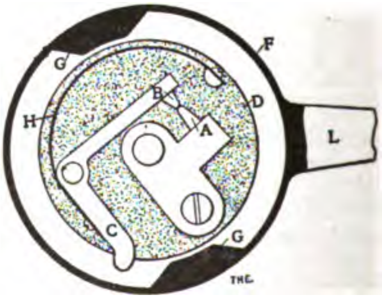


Fig. 5—Circuit Closed on Interrupter.

HART NO. 131—Parts of the High Tension Magneto. Compound Wound Armature. **Magneto** Interrupter or Breaker. Pole Pieces and Base.

The winding of heavy wire, or primary winding, serves primarily for generating the current, and in connection with the fine wire or secondary winding, it also serves for multiplying the pressure or voltage to such an extent that it will produce a spark at the gap of the spark plug in the cylinder. **Types of armatures** are shown in chart 132.

The interrupter, also called a "contact breaker." To accomplish this breaking of the primary circuit at the proper moment and then closing it again, a device known as a circuit breaker or interrupter is used. This is carried on the armature shaft opposite the driving end.

It consists essentially of a stationary insulated contact point (A), (see fig. 4, chart 131) and a movable contact point (B) on one arm of the bell crank (C). Both of these parts are mounted on a brass disc. (D), which is securely fastened to the armature shaft and rotates with it.

The stationary contact (A) is insulated from the supporting disc (D), while the movable contact (B) is in metallic connection with it, and the disc (D) is grounded to the frame of the magneto by a carbon brush (E). (See fig. 2, chart 129.)

The circuit breaker is surrounded by a cylindrical housing (F), to the interior surface of which, at diametrically opposite points, are secured steel cam blocks (G & G.)

Ordinarily the two contact points (A and B) are kept in contact by a spring (H). As the disc (D) rotates, the outer arm of the bell crank (C) comes in contact with the cam blocks (G), whereby the contact points (A and B) are separated momentarily.* (Fig. 4, chart 131.)

As soon as the end of the bell crank (C) passes cam block (G) the spring (H) brings the two contact points (A and B) together again. (Fig. 5, chart 131.)

The stationary contact block (A) is connected with one end of the primary winding of the armature, through a screw passing through the center of the armature shaft. (See (I) fig. 2, chart 129.)

The other end of the primary winding has metallic connection with the armature core; in other words, it is grounded.

It will now be readily understood how the current flows through the primary circuit (fig. 1, chart 129). Originating in the primary winding (P W, fig. 2) on the armature, it flows through the contact breaker screw (I) to the stationary contact (A), thence across to the movable contact (B), from which it is led through the contact brush (E), into the metallic framework of the magneto, whence it returns to the beginning of the primary winding, which is also connected or grounded to the frame. (Study fig. 1, chart 129.)

****Condenser principle:** When the two contact points (A and B) are suddenly separated there is a tendency for the current to continue to flow across the gap, it possessing a property similar to the inertia of matter. This would result in a hot spark being formed between the contact points, which not only would burn the points away rapidly, but also would prevent a rapid cessation of the current, which as already explained, is necessary in order to effect a rapid change in the lines of magnetic force through the armature and a high inductive effect in the secondary winding. To obviate this effect a condenser (J, figs. 1 and 2, chart 129) is employed, which in the Bosch magneto is placed in a hollow of the armature end cover at the circuit breaker end, also see chart 132.

Condenser construction: This condenser consists of two sets of tinfoil sheets, sheets of opposite sets alternating with one another, and being separated by sheets of insulating material. All the sheets of each set are metallically connected, and one set is connected to the conductor leading from the primary winding to the stationary contact point (A), while the other set is grounded. In other words, the condenser is **shunted across the interrupter.** See fig. 1, chart 129 and fig. 5, chart 109.

Such a condenser is capable of absorbing an electrical charge, and its capacity is so proportioned that it will take up the entire charge of the extra current produced when the contact points (A and B) separate; that is, the extra current, instead of appearing in the form of a spark across the gap between A and B, passes into the condenser (J). In this way the objectional arcing or burning at the contact points is avoided and the current flow in the primary circuit is more quickly stopped.

The safety spark gap principle: There remains but one point to describe, and that is the safety spark gap (see Z & ZZ, fig. 2, chart 129). This is practically a safety valve for the high tension current. If, for example, a wire became detached from the sparking plug or from the distributor so that the ordinary path of high tension current was barred, there would be considerable danger of the current forcing a circuit through the insulation of the armature, and thus doing very considerable damage were it not given some easier escape as provided by the safety gap.

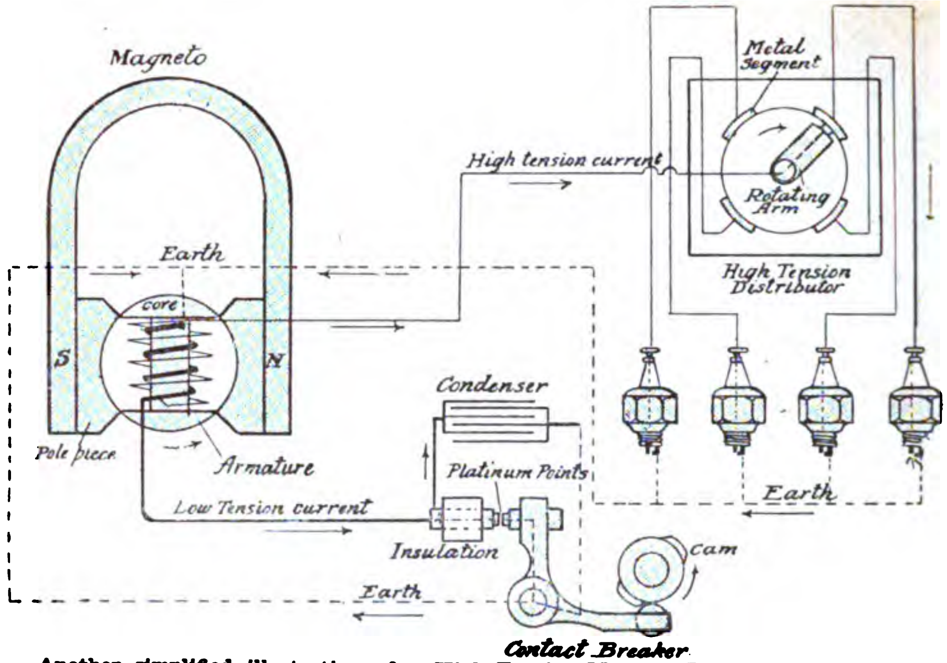
A magneto must be so designed that it will give a sufficiently hot spark at a comparatively low engine speed, and the ability to do this implies the ability of generating very large and hot sparks and enormously high tensions at high engine speed.

The actual electro-motive force or tension produced in the secondary winding is, however, limited by the size of the spark gap in the spark plug, for as soon as the ten-

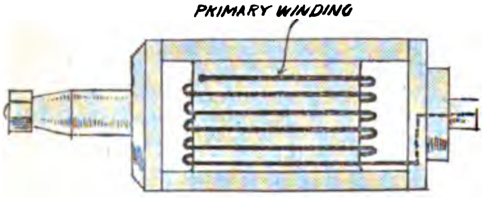
---

*The breaker points on the Bosch are usually set .016 in. gap, spark plug gap .025 in.

**The condenser increases the volume of spark about ten times—see also page 229. See page 303, testing a magneto condenser.



Another simplified illustration of a High Tension Magneto Ignition System, showing the circuit of the primary wire winding on the armature and its connection with the interrupter. Note the condenser is "shunted" across the interrupter. Another view shows the distributor and spark plugs and connections. Dotted lines represent the earth or ground connection to frame.



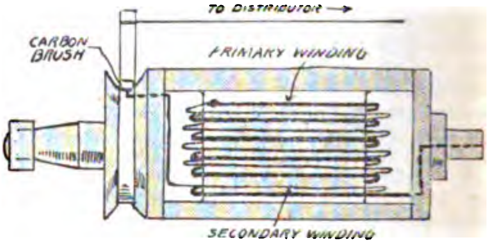


Fig. 2. Primary Armature, Single Wound. Fig. 3. Compound Armature, Double Wound.

Magneto armatures may be classified in two groups, according to the basic principles employed in the magneto field to generate the initial electrical impulses. These are known as the ARMATURE type and the INDUCTOR type.

Armature type.—Electrical current is generated in the armature type magneto by revolving several thousand feet of fine copper wire, which is wound around a soft iron core, between the pole pieces of the magneto. As the winding rotates within its narrow confines, electrical impulses are set up within the winding.

The armature type magneto may be redivided into two classes. One is called the PRIMARY ARMATURE magneto, and the other is called the COMPOUND ARMATURE type.

The primary armature type has but a SINGLE winding in the magneto field and generates a low voltage current and is described in Chart 120 as the LOW TENSION MAGNETO.

The compound armature type is the DOUBLE wound armature described previously (Chart 131) as the HIGH TENSION, DOUBLE WOUND ARMATURE TYPE OF MAGNETO.

The inductor type of armature is a little different from the armature previously described. This type consists of revolving a solid steel shaft, upon which are mounted two steel, fan-shaped inductor wings, within a stationary winding in the magneto field. (Chart 126.)

In this type the wire does not revolve or move as it does in the armature on the magnetos previously described. The fan-shaped wings and shaft revolve, while the wire remains stationary.

This type of magneto requires a separate high tension coil (transformer), which is placed separate from the magneto, as shown in Chart 123; therefore it would be called a low tension magneto with a separate high tension coil.

The type of magneto using the inductor type armature is the REMY and K. W. make.

NO. 182—Another Diagram of a High Tension Magneto Circuit. Magneto Armatures.

sion reaches a point sufficient to jump this gap the discharge occurs, and there is no further increase in the electro-motive force.

Suppose however, that the terminals of the spark plug are by chance bent unduly far apart, or that one of the high tension connections to the spark plug accidentally comes loose, then there would be no chance for the spark to pass in the ordinary way and the electro-motive force in the secondary winding might build up to such an extent as to puncture the insulation of the winding which would ruin the armature. To avoid this the safety spark gap is provided.

Safety spark gap construction: It consists of a little chamber formed on top of the armature cover plate with a top of insulating material. Into the top and bottom of this chamber, spark terminals (Z1, Z2) are set.

The spark terminal in the bottom is, of course, grounded, and that in the insulated top is connected with a high tension contact brush (P) by a strip connector.

The gap between the two terminals (Z1, Z2) is longer than the gap between the spark plugs. and ordinarily no spark will pass between these terminals, but if owing to the conditions already mentioned, no spark can pass at the regular spark plug and the electro-motive force in the secondary winding attains an abnormal value, a discharge will occur at the safety spark gap, thereby preventing the secondary electro-motive force from rising still higher.

Miscellaneous Details of Construction.

Some of the mechanical details of the magneto may be seen in charts 129 and 130, which are three actual views of the Bosch model DU4. It will be observed that a spring-pressed contact brush (a, fig. 2, chart 129, extreme bottom) is placed in the base of the magneto bearing against the circumference of one armature end plate. The object of this contact brush is to make absolutely sure that the revolving metallic parts of the magneto are at all times in good metallic connection with the stationary part and the frame of the car; in this construction, therefore, the armature bearings carry no current.

The armature shaft is mounted in annular ball bearings (fig. 2, chart 129) (b and c), which are provided with oil guards so that any lubricant supplied to them will not be easily lost or reach the insulating parts. The armature tunnel is closed on top by an aluminum cover (i) and the front of the circuit breaker housing is provided with a brass cover (g), which is held in place by means of a hinged flat spring (h), so it can be very quickly removed and replaced.

The distributor shaft is mounted in a plain bronze bushed bearing, which is lubricated by means of a wick oiler (e). A felt washer (d) encloses the inner end of the bearing, while at the distributor end is provided a channel (j) for the escape of any oil working out of the bearing so it will not reach the distributor. A large size oil well (o) is provided for the wick oiler and is closed by a hinged cover (f) on top.

A number of other illustrations are also shown of the Bosch DU4 magneto, in chart 130 and 131, which may aid those not familiar with mechanical drawings to grasp the arrangement of parts.

So far as the above description of the individual parts and their functions is concerned, that applies to any true high tension magneto, that is, a magneto having both a low tension and a high tension winding on the armature.

Each of the elements here described is always present, and serves the purpose indicated, though the relative location of the parts varies somewhat.

To Cut-off the Magneto Ignition—The Switch.

It is necessary to be able to stop the magneto from producing sparks when it is desired to stop the engine. (See fig. 2, page 270). To this end a sheet metal strip (K) is provided which contacts with the stationary contact point (A) of the circuit breaker and leads to a binding post (M) on the circuit breaker housing. From this binding post a wire is carried to a switch on the dashboard. One side of this switch is grounded.

When the switch is closed the current generated in the primary winding of the armature flows to contact point (A), thence through strip (K), binding post (M), and connecting wire to the switch, whence it passes through a wire into the framework of the car and returns to the beginning of the primary winding. The effect of this is that the primary winding is "short circuited" all the time and the opening and closing of the contact points (A and B) have no effect. In technical terms, **the circuit breaker is cut out.**

The flow of the primary current can easily be followed in the diagram of connections (fig. 1, page 268) where its direction when the magneto is working regularly is indicated by full arrows, and its return path when the magneto is running but not producing sparks, is indicated by dotted arrows.

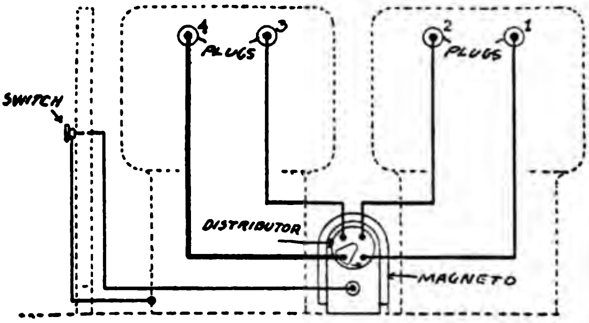


Fig. 1—A "Single" high tension magneto; Engine is started direct from magneto current. Current is distributed to plugs. The switch connects to interrupter on magneto on one end, and "ground" on the other. To stop magneto, the switch is closed, not opened.

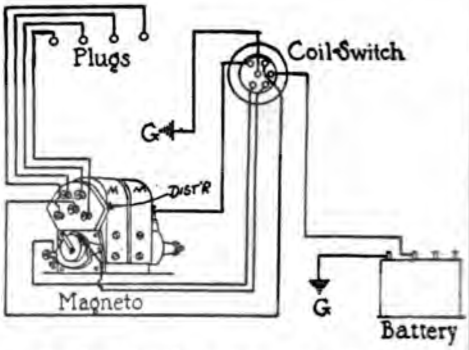


Fig. 2—A "Dual" system of ignition; Either the high tension single coil with battery (using the distributor on magneto) may be used or the high tension magneto alone may be used. Only one set of spark plugs.

The "Double" system of ignition; high tension magneto and a separate single high tension coil with a separate timer and distributor combined, using a battery.

The positive terminal of the battery is grounded and the negative terminal led to terminal (5) of the stationary switch plate. Switch terminal (1) is then connected with the binding post located on the under side of the timer-distributor (T D). The second binding post on the timer-distributor, which is located on the under side of the timing control arm, is to be grounded.

Switch terminal (2) is connected to the grounding terminal of the magneto.

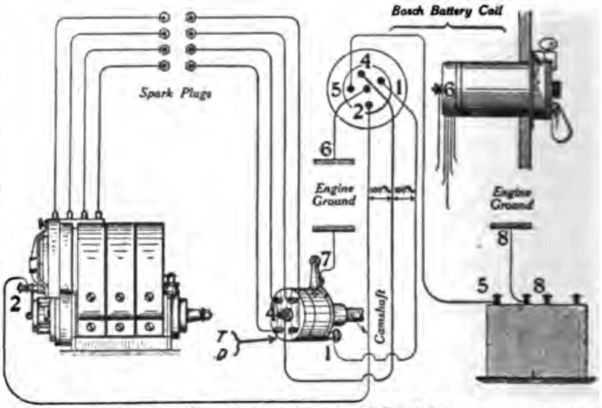


Fig. 3.—Bosch "Double" System of Ignition—two sets of Spark Plugs and two Independent Ignition Systems.

The cover of the Timer-Distributor may then be replaced, but a careful note should be made of the distributor terminal with which the distributor brush is in contact. This distributor terminal should be connected to the proper spark plug of the cylinder with which the distributor of the magneto is in circuit. The remaining distributor contacts should be connected in accordance with the firing order of the engine, and will, of course, be identical with the connections of the magneto. Switch contact (4) is then to be connected to the central contact of the timer-distributor, and this will complete the connections.

When the switch is in the off position, the battery circuit is broken and the magneto is grounded, in consequence of which no sparks will be produced when the motor is cranked.

With the switch thrown to position (B), the magneto will continue grounded, but the battery circuit will be completed, and in consequence, the breaking of the circuit by the timer-distributor will result in the production of a spark that will be transmitted to the proper cylinder by the distributor.

The same condition will exist with the switch thrown to position (MB), except that then the magneto ground circuit will be broken and that magneto sparks will be produced in addition to the battery sparks.

With the switch thrown to position (M), the magneto will operate in the normal manner, and the battery circuit will be broken.

CHART NO. 133—Magneto Wiring Diagram of a High Tension Magneto; "Single," "Dual" and "Double" Ignition System.

Note—The system fig. 3, is known as the "Bosch Battery, Coil and Timer-Distributor" system and is similar to system explained on page 253.
See foot note bottom of page 281.

Examples of Magneto Systems.

Until the perfection of the modern magneto the ignition system of any car was always regarded as one of its weakest points. To spend 20 minutes in testing one's ignition before starting on a journey was considered almost as essential as pouring gasoline into the tank or oil into the lubricator. In fact, these two latter processes became somewhat secondary.

So deeply had the fear of ignition troubles taken root in the motorist's mind, that the advent of the magneto was welcomed, not as a substitute for the old system, but as the saying went, as "a second string to the bow." To suggest a magneto only, drew forth the wearisome remark, "If the magneto gives out, what am I to do?" Though why it should have been supposed that the magneto was wrapped in more mystery than the storage battery and coils with their 20 to 50 yards of insulated cable, its contact breaker and delicate trembler blades, is not easy to explain. Perhaps the old evils were preferred to possible new ones. At any rate, it became the fashion to fit two ignitions—the magneto machine and the storage battery and coil; to run on the magneto and to use the other system as a stand-by, should the magneto break down.

Dual Ignition.

Dual ignition is quite common where magnetos are used as a source of mechanical electrical supply of current. Some means of supplying a current without having to generate it mechanically is usually employed.

In chart 124 a method is described as used in connection with a low tension magneto. To apply a similar method to the high tension magneto it is merely a matter of carrying out practically the same principle. In order to bring out the methods, we will first start with high tension magneto supplying current for ignition without the use of an auxiliary system.

High Tension Magneto Alone.

In fig. 1, chart 133, note the high tension magneto supplying current to the four spark plugs on a four cylinder engine.

The armature is double wound; therefore a separate coil is not necessary. The distributor on the magneto distributes the high tension current to the spark plugs.

The objection to this system is that in starting, the armature on magneto must be revolved fast enough to generate current before the spark will occur at the plugs. Therefore it is necessary to "spin" the crank. This is not a very satisfactory system.

A Dual System.

Fig. 2, chart 133, illustrates a high tension magneto with a separate battery and high tension coil. The coil is of the round pattern, usually placed on the dash, with a *kick switch on its face. The starting is by battery and coil using the magneto distributor. After starting, the switch is placed on magneto side, and the magneto supplies the current and coil and battery are cut out entirely. On all dual systems of ignition only one set of spark plugs are used.

Double Ignition.

A double ignition system, known as the Bosch battery and coil, timer, distributor system comprises two separate and distinct systems with two sets of spark plugs. See fig. 3, chart 133. This system consists of practically the single vibrator coil and a separate timer and distributor, as described in fig. 1A, chart 110. It is entirely independent from the high tension magneto system. Note (T-D)) is the timer and distributor; (5), the battery; (6), the vibrator coil with kick switch.

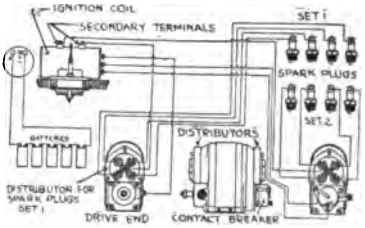
The other part of the system, is a high tension magneto (2). Note the only connection this system has with the coil system, is its connection with the switch at (2) on back of coil. If one system fails, the other is entirely independent.

Another form of Double System.

Referring to chart 133A, note the separate and independent high tension magneto. The coil and battery system is similar to the master vibrator system, explained in chart 110. The chart will give further explanation.

Two-Spark Ignition System.

The "two-spark" system used in connection with a high tension magneto is explained on page 283 and below. Here we have two distributors on the one magneto and two spark plugs are provided for each cylinder.



Remy two-spark magneto.

The object is to increase the power and speed, explained as follows: The object of advancing the spark is to compensate for the slow development of the explosion pressure, for the early stages of the development are relatively very sluggish. It is for this reason that double pole or two spark ignition is advantageous, namely, because it increases enormously the rate of development and a much less degree of advancement is therefore necessary, with the result that power is gained through avoiding the back pressure at the top of the compression stroke, which is otherwise bound to result from an abnormal advancement.

Two-Point Ignition System.

The "two-point" system, where two sparks occur at the same time but in different cylinders, is shown on page 284.

On a four cylinder engine, the spark would occur at two spark plugs at once, but inasmuch as one of the pistons would be on exhaust stroke, this would make no difference.

***Kick switch** means, the switch can be kicked from one side to the other by foot.

This system is what would be termed a "Double Ignition," in that it has two sets of plugs and two independent systems of ignition, coil and magneto.

A Synchronized (multiple unit) Autocoil is used in conjunction with the battery system only. The coil case contains six Non-Vibrator Unit Coils and a Master Vibrator. Each Non-Vibrator Unit Coil has a test key for locating troublesome Plugs and each Unit also has a Safety Gap or telltale device to indicate the accidental opening of the secondary circuit.

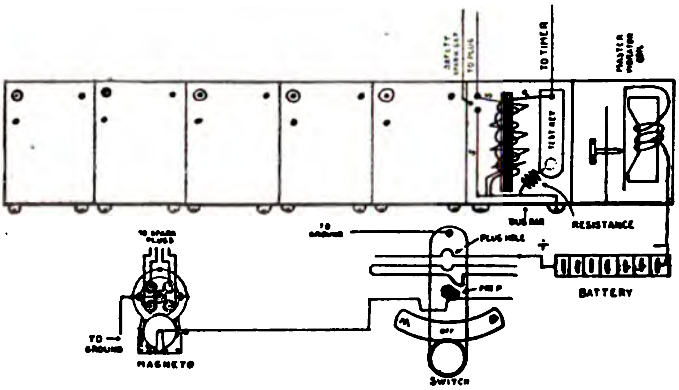


Fig. 1—Diagram of the Coil and Switch.

When switch lever is in "Off" position, **Magneto is grounded through Pin (P) to lever, and Battery circuit is open. When in (B) position, Magneto is still grounded and Battery circuit is closed, providing plug has been inserted in switch hole. When in (M) position, Magneto is not grounded and battery circuit is open on account of Pin (P) being removed from** spring above it.

Fig. 1 shows a complete diagrammatic circuit of the Switch, Master Vibrator and one Unit. The other five Units are identical with the one shown and are connected to the common strap along the front of the case, as shown by the screws in Figs. 1 and 3.

The test key is normally open until it is depressed for testing, when it causes the current to flow through the resistance (R) and through the primary. This resistance is arranged so that there is not sufficient current passing through the primary to produce a spark in the secondary circuit; hence when the key is depressed, the spark in that particular cylinder is cut out.

Spark Gap—One side of the gap is connected to the high potential side of the secondary winding, the other to the low potential side of the secondary winding. This permits the spark to jump across the gap without doing damage to the internal construction of the coil, if for any reason the wire to the spark plug should become disconnected, or the points of the plug set too far apart.

The low potential (voltage) side of the magneto primary is grounded to the engine frame through the bolts which hold it in place.

The wire marked "To Ground" should run to the frame of the engine.

It is a simple matter to trace the circuit from the battery through the Master Vibrator, through one of the Coil Units, to the Timer, to Ground, whence it returns through the Ground wire to the Switch Lever. If it is turned in the (B) position, the Magneto will be grounded and the battery circuit complete when plug is inserted in the plug hole.

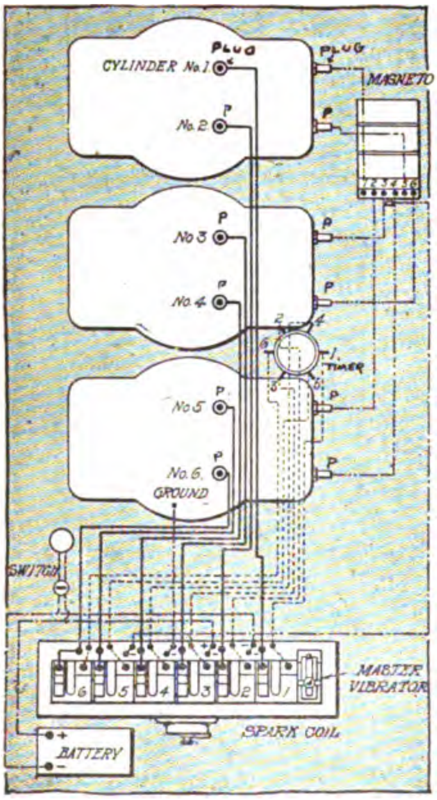


Fig. 2.—View of connections from coil to cylinders and commutator, and magneto to cylinders.

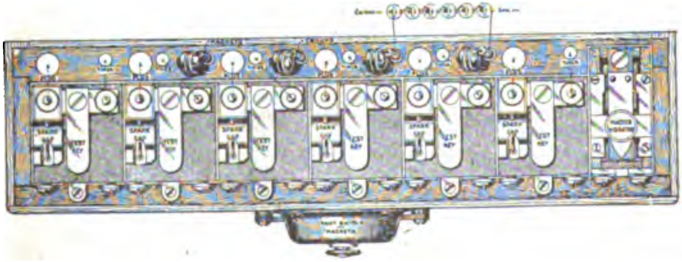


Fig. 3.—Top view of the coil used on the Pierce six cylinder car.

The coil system being the Master Vibrator type similar to system explained in chart 110, fig. 1.

The Magneto system above is the usual high tension type.

CHART 183A—Example of a "Double" Ignition System Using a High Tension Magneto and a Multiple Type Coil (formerly used on **Pierce Arrow**—now obsolete—merely shown as example).

Bosch Vibrating Duplex System.

This system is described in chart 137. Its purpose is to assist in starting. Do not confuse this system with an electric system of starting by movement of crank shaft. The principle of this system is to supply a separate battery and vibrating coil to start engine on, doing away with a dual system. See chart 137 for further description.

To Time the Magneto.

Which is a Bosch DU4 or DU6 as an example. First place piston of No. 1 cylinder on top of compression stroke, and with magneto interrupter housing retarded set contact points just starting to break. The driving means can then be coupled up.

The timer distributor, fig. 3 chart 133, should then be revolved (in direction of rotation) until timing interrupter is in the act of breaking.

To Time the Eisemann "G" Types.

With these systems it is merely necessary to bring No. 1 piston to top dead center, rotate the magneto until the setting mark on the distributor is opposite the pointed screw at the top and couple up the drive. Use marks "R" or "L" for right or left hand rotation, respectively, as needed—rotation being judged from driving end. (see page 285.)

Instructions to the Reader.

If the reader will master the purpose and principle of the following, it will then be easy to analyze any system of ignition he may come across. For instance, learn the difference between; low tension coils, high tension coils; low tension magnetos, high tension magnetos.

Other details to classify would be; the difference between the commutator, timer and interrupter, and sources of electric supply, as direct current chemical generators; (dry cells and storage batteries). Direct current, mechanical generators; (dynamos). Alternating current, mechanical generators; (magnetos).

Methods for distributing the secondary current to the spark plugs; by a distributor as used on a magneto, or by a commutator in connection with a vibrator coil. In other worls, very nearly all of the systems compose one or more of the parts of the four principles of ignition.

Difference in Makes of Magnetos.

An inspection of the illustrations of the different leading makes of magnetos shown in chart 141 will give the reader an idea of the variance in construction. In this chart we illustrate magnetos of the low tension type and magnetos of high tension type.

As previously explained, the low tension type of magneto employs an armature wound with only one winding of wire, which is called the **primary** winding. We learned in a previous instruction that when a magneto employs a single primary wound armature, then a transformer (high tension coil) separate and distinct from the magneto, is necessary in order to step up or transform the low tension voltage, (pressure) up to a high pressure.

By referring to chart 141, we find that the Remy and Splitdorf (in the models shown) have **primary** wound armatures and need separate coils or transformers. But going a little further into detail, we find that the Splitdorf, Eisemann, Bosch, Mea and the pivoting magnetos all have armatures which **revolve with the winding** wound on the revolving part.

In the Remy and K. W. we find that the winding does not revolve, but is stationary.

"Armature" and "Inductor" Type; "Primary" and "Compound" Wound Magnetos.

The revolving type of armature, with the wire wound thereon, is called the "armature" type, and the type where the wire is stationary is called the "inductor" type.

If there is only one winding it is called a "**primary**" wound armature. **If there are two windings,** then it is called the "**compound**" **type.** (see chart 132.)

The primary wound armatures are low tension, and require separate coils.

The compound wound armatures are high tension, and do not require separate coils —only as a matter of convenience for easy starting or dual systems of ignition.

We will now go back to the "armature" and the "inductor" type. Up to the present we've shown only the Remy and K. W. with an inductor type of armature, with a single, primary winding.

By referring to the K. W. magneto, in chart 141, we find that the winding on this type is also stationary, but instead of being a single primary winding, as on the Remy, it is a double or compound wound armature like the Bosch, Eisemann and Mea —but differs from the last mentioned in that the winding **does not revolve.**

In the Bosch, Mea, and Eisemann the armature is compound wound and of the "armature" or **revolving type.** The principles of the magnetos are about the same, with some few minor differences in construction.

"Pivoting" or "Rocking" Type Magneto.

The Mea magneto differs in that the magnets can be turned from side to side (called pivoting type); they are bell-shaped, and placed horizontally; therefore, unlike the customary horse shoe type, mounted vertically. In this construction the magnets and breaker are moved simultaneously instead of the advance and retard of contact breaker alone.

—continued on page 287.

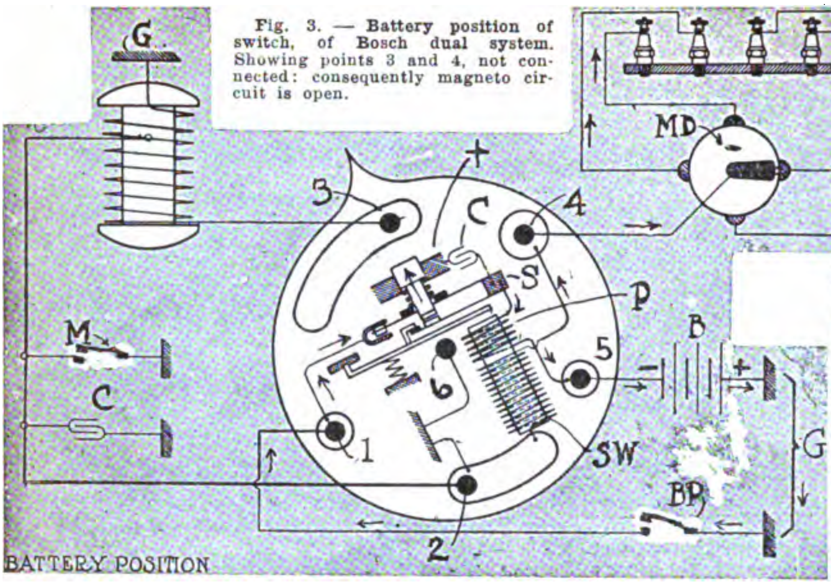


Fig. 3. — Battery position of switch, of Bosch dual system. Showing points 3 and 4, not connected: consequently magneto circuit is open.

Bosch Dual System.

This system consists of a vibrator coil and battery, using the interrupter housing of the magneto for the addition of a separate timer to make and break the primary current of the vibrator coil. (see fig. 9, chart 136.) The same distributor is utilized for both systems, also one set of spark plugs.

The high tension magneto is of the usual type. The only difference being in the addition of the timer, which is independent of the magneto interrupter, but mounted on the same housing.

Fig. 3 shows the switch in battery position and figs. 4 and 5, chart 135, shows switch in "off" and "magneto" positions.

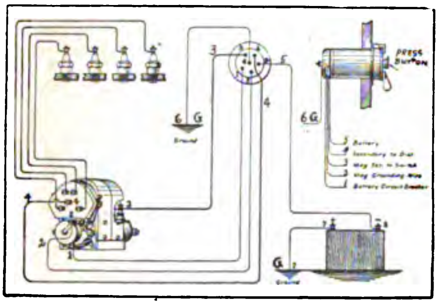
Let us first see what happens when the switch is thrown on the battery side of the coil as shown in fig. 3. The current in the battery, B leaves it at the positive side and travels through the ground wire G, which is attached to it. It goes then, through the breaker points BP, which are operated by a cam. The course then is to the post 1, through the mechanism in the direction of the arrows, to point, S.

It flows then through the primary winding, P, of the coil, and as the arrows show through point 5 back to the battery. Thus the primary battery circuit is complete.

In passing through the primary winding, a high-tension current is set up in the secondary winding, SW, when the breaker points separate.

This high-tension current flows to the distributor wire at 4. Thence to the magneto distributor, MD. Here it is passed to the different spark plugs in order.

It goes through the plug to the base of the cylinders to ground.



WIRING DIAGRAM OF THE "DU" DUAL SYSTEM

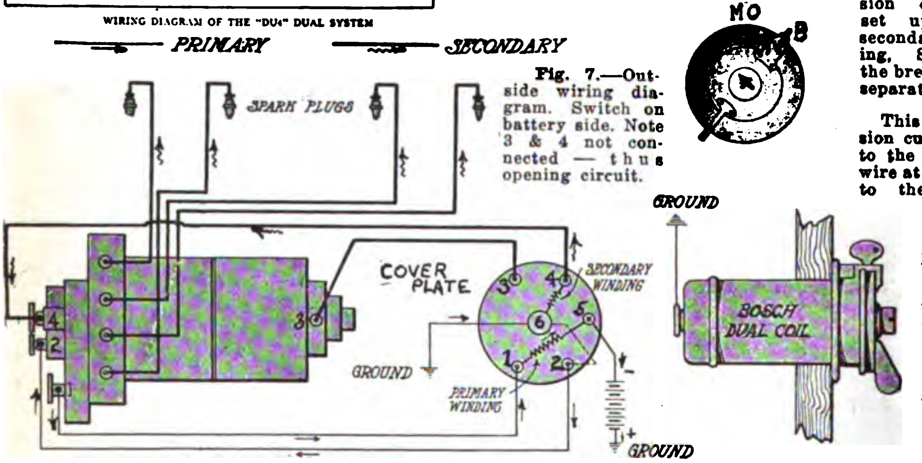


Fig. 7.—Outside wiring diagram. Switch on battery side. Note 3 & 4 not connected — thus opening circuit.

However, one end of the high-tension winding is grounded through brass bus bar, to 6. Therefore the current flows back to the high-tension winding, where it was induced, by means of the ground wire. This completes the battery system of the Bosch dual system. C in fig. 3 represents the condenser, of which there are two, for the purpose of protecting the contact points.

In fig. 7 the outside wiring of the battery system is made clear. The current leaves the battery at the positive terminal and travels to the ground. As 6 is grounded the current goes to 6 thence to 2 and along 2 to the magneto. Then to 1 on the magneto, and along the wire as indicated by the arrows to the point 1 on the switch plate. Here it travels through the primary winding of the coil then to 5 and back to battery as before. thus completing the circuit.

A point that is very confusing in this, is that the coverplate or plate with the marks 1, 2, 3, 4, 5 and 6, in fig. 7 may be taken for the coil end in fig. 3. The cover plate in fig. 7 remains stationary.

When the switch is turned the whole mechanism in fig. 3 with the marks 1, 2, 3, 4, 5 and 6, moves. When the switch is thrown on the battery side the point 1 on the cover plate lines up with 1 on the coil, likewise 2 and 5 line up with 2 and 5 on the coil. In reality they are brass busbars or segments. On the cover plate the numbers represent binding posts for wires.

Battery—ten dry cells, or a 6 volt, 60 ampere-hour battery can be used with the battery system.

HART NO. 134—Bosch Dual Ignition System—continued in charts 135 and 136.

iring connections from distributor to spark plugs are not in regular firing order. Main purpose of diagra to show Switch Circuits.

—continued from page 280.

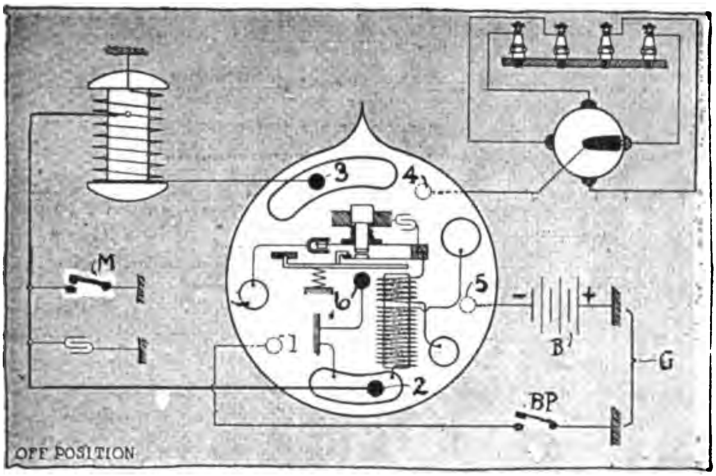


Fig. 4—Switch in off position showing points 1, 2, 4, and 5 not in contact. In this position all circuits are open

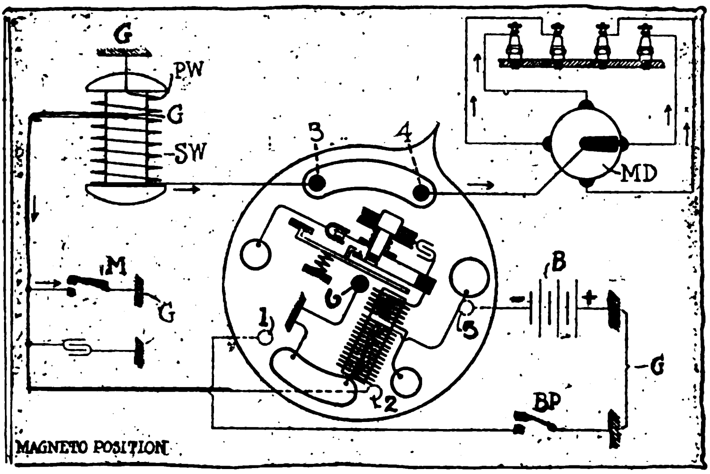


Fig. 5—Switch in magneto position showing but one closed circuit; it was made by connecting 3 and 4

In the off position of the switch, fig. 4, there can be no circuit because the points 1, 2, 5 and 4 of the plate do not coincide with points 1, 2, 5 and 4 of the coil. All the circuits are open.

As soon as the switch is thrown on the magneto side, see fig. 5—the busbar with which 3 is in contact in fig. 3 connects also 4. But the other points do not make contact. In other words the only complete circuit is through 3 and 4.

Now, the magneto is turning around and a low-tension current is set up in the primary winding PW, fig. 5 of the magneto coil. This current flows through a wire to M, the magneto breaker points and from there to the ground G. But the other end of the primary winding of the magneto coil is grounded, therefore the circuit is complete.

In passing through the primary winding the current induces a high-tension current in the secondary winding, SW, which goes immediately to 3. Now, 3 and 4 are connected by the brass busbar, therefore the current will flow from 3 to 4. The latter has attached to it the distributor wire. The current will flow then through the distributor wire to the magneto distributor MD, and thence to the spark plugs. Here the current is grounded. The other end of the high-tension winding is grounded also, again the circuit is complete.

In throwing the switch to magneto side, every circuit but that made by 3 and 4 is open. In fig. 5 it will be noticed that 1, 2 and 5 are in no way connected. That happened because the coil was switched around and the little brass plates were thrown out of contact with the points 1, 2, 5 and 6.

In fig. 6, chart 136, the magneto outside wiring is made clear. The high-tension current generated in the magneto armature leaves the magneto by the armature wire at 3. (It travels to 3 on the cover plate.) Thence to the distributor wire at 4 and to the distributor where it is sent to the spark plugs.

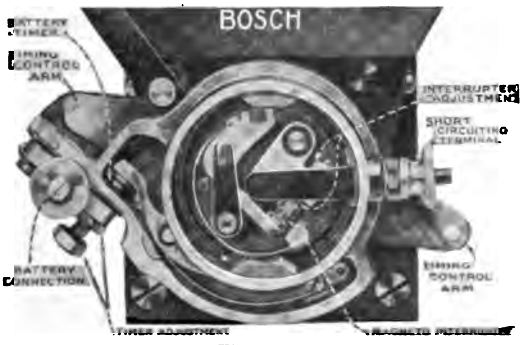


Fig. 6A.

In order to start the engine with the starting handle or electric starter—the press button, fig. 9, chart 136, is pressed down and then turned at right angles, a process which locks it in position for the trembler spark, for it will be admitted that this will be the best ignition on which to get the initial explosion when the engine is turning slowly.

Timer and interrupter: Regarding the magneto itself (fig. 6A), it will be observed that two alterations have been made to it in order to adopt it to the dual system. Firstly, a second contact breaker has been fitted below the ordinary one, which is operated by cams on the contact breaker base above. It must be thoroughly understood that this second contact breaker has no electrical connection whatever with the magneto. The object in placing it in this position is to confine the working parts of the dual ignition to as small a compass as possible, and to reduce the wiring to a minimum.

The second alteration consists in the removal of the bridge which in the ordinary magneto connects the high tension slip-ring and current collector, direct to the distributor; now that the distributor is to do duty for two ignitions, it is necessary that the current be carried to it via the switch.

CHART NO. 135—Bosch Dual Ignition System—continued.

In practice, connections from distributor to spark plugs are not as shown; if so, it would fire 1, 2, 3, 4, wheres it should connect to fire 1, 2, 4, 3 or 1, 3, 4, 2. Main purpose of diagrams is to show Switch Circuits.

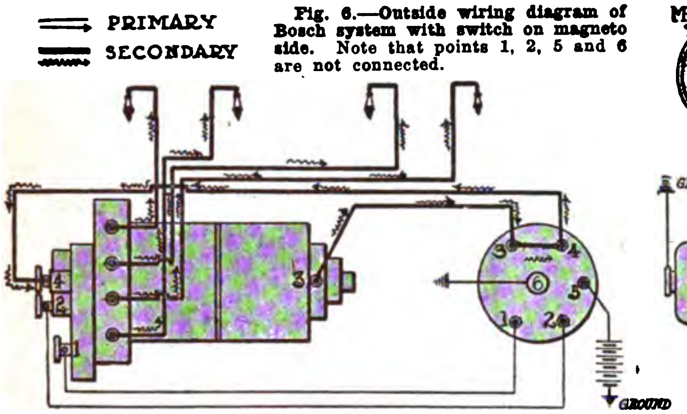
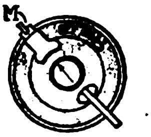
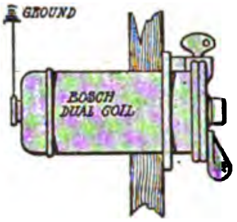


Fig. 6.—Outside wiring diagram of Bosch system with switch on magneto side. Note that points 1, 2, 5 and 6 are not connected.





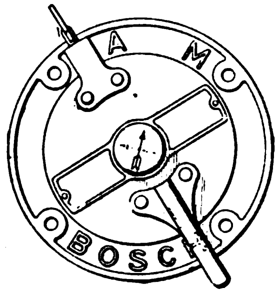
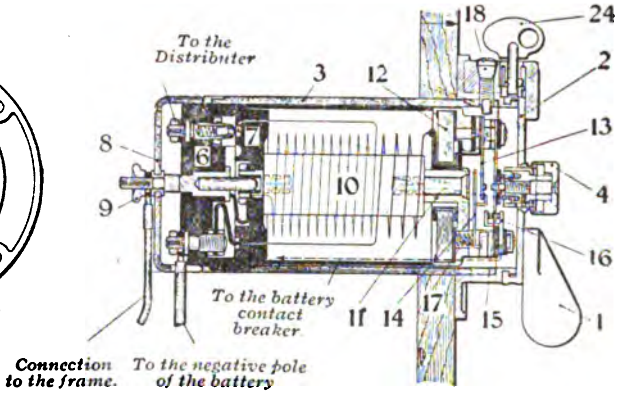


Fig. 8.



1. *Switch handle.*
2. *Movable cover*
3. *Coil case.*
4. *Starting press button.*
6. *Fixed connection plate.*
7. *Movable switch blade.*
8. *Cable cover.*
9. *Milled edged nut.*
10. *Iron core.*
11. *Plate carrying the starting arrangement and the condenser*
12. *Condenser*
13. *Contact spring.*
14. *Trembler*
15. *Auxiliary contact*
16. *breaker*
17. *Trembler spring*
18. *Stop screw for switch handle*
24. *Locking key*

—continued from page 280, 281.

The coil of the Bosch dual system is fitted into a vulcanite cylindrical box, which is attached to the dashboard, fig. 8.

The switch. The face of the coil box is also the switch, so that in moving the switch handle to (M), the magneto ignition, or to (A), the storage battery ignition, the whole coil is rotated inside the coil box. This eliminates a separate switch and all the wires connecting to it.

To start the engine on the switch or ignition as it is sometimes termed, the storage battery is first turned on and then the brass button in the center of the switch is pressed. If the engine has a charge of gas in it, it will start at once. If it should be found that the engine cannot be thus started, it is then necessary to use the starting handle as explained in charts 134 and 135. (Electric starters now so universally used obviates necessity of cranking).

An explanation of the coil. To explain exactly how the self-starting is accomplished, see fig. 9. The storage battery is supposed to be switched on. Starting from the left hand storage battery terminal (to make it easier to understand), the current passes through the primary winding and arrives at the end of the trembler blade and the blade above, called the auxiliary contact breaker. The current cannot travel beyond the trembler blade because, as will be seen, the platinum points are separated. Neither can it complete circuit along the auxiliary contact breaker blade because the main contact breaker (left hand lower corner) also stands open, being the position in which the contact breaker always comes to rest when the engine stops, save for the few occasions when the engine stops with the piston about dead center.

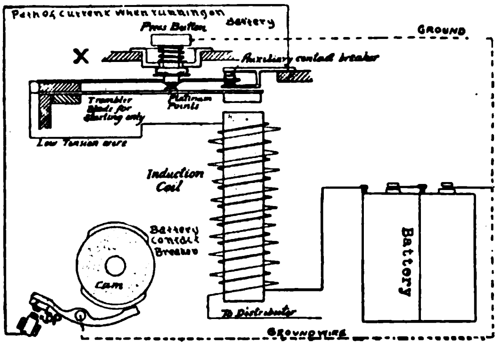


Fig. 9.

To start the engine therefore, we have only to press the button so that the upper platinum point comes into contact with the lower one, and immediately the circuit will be completed, the trembler start buzzing and a shower of sparks sent through the plug of the cylinder which is next to fire. Now the work of the trembler blade is done, the engine has started and the main contact breaker is set in motion. The current troubles no longer about the trembler blade, but follows the upper path along the auxiliary contact breaker and through the main contact breaker, the making and breaking of which does the work of the trembler and creates the high tension current. The engine may be kept running in this manner at the pleasure of the driver.

The auxiliary contact breaker, fig. 9: Now let us take the exceptional case of the engine stopping with the pistons about dead center and the main contact breaker points closed. The current this time finds an easy circuit through the closed points, the iron core becomes magnetised, the trembler blade is held down on the core, and pressing the button as before has no effect. No spark is made because there is no break in the circuit. But if the reader will examine the diagram closely, he will observe that the act of pressing the button presses the auxiliary contact breaker blade away from its upper platinum point and on to its lower one, the momentary break thus caused in the circuit being sufficient, under the circumstances we are supposing, to create the necessary high tension current for the spark in the cylinder and so start the engine.

When the engine stops in the more usual way with the storage battery contact breaker open, the opening and closing again of the auxiliary contact blade has no effect. The diagram, fig. 8, shows the coil as it actually exists.

CHART NO. 136—Bosch Dual Ignition System—continued. To time this magneto, see page 311.

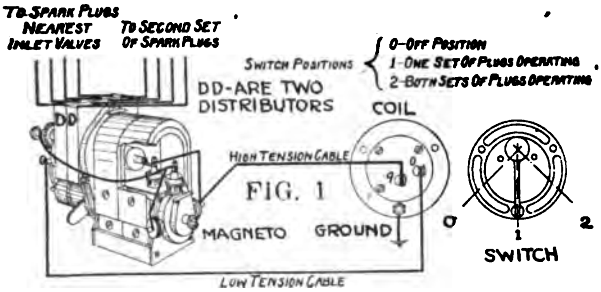

To Spark Plugs Nearest Inlet Valves
To Second Set Of Spark Plugs
Switch Positions
0—Off Position
1—One Set Of Plugs Operating
2—Both Sets Of Plugs Operating
DD-ARE TWO DISTRIBUTORS
DD
COIL
High Tension Cable
MAGNETO
GROUND
Low Tension Cable
0
1
2
SWITCH

FIG. 1

Bosch Two-Spark Independent Magneto Ignition System

The purpose of the Bosch two-spark magneto (fig. 1), is to produce ignition at two plug points in each cylinder, in order to reduce the time interval between ignition and complete combustion; and, where it is possible to locate the spark plugs as shown in chart 140. The result is to reduce the ignition advance necessary, and thus to secure an increase in the efficiency and output of the engine.

Bosch two-spark magnetos are produced in types ZR4 and ZR6, in either independent or dual form. In appearance, they are similar to the single-spark magnetos of corresponding types, the noticeable difference being a distributor of double thickness, and the arranging of a second safety spark gap under the arch of the magnets.

In the single-spark magneto, the beginning of the armature secondary circuit is grounded on the armature core through the armature primary circuit, whereas in the **two-spark magneto**, the two ends of the armature secondary circuit, are connected to two sectional metal segments, diametrically opposite on a single slipring. **Two slipring brushes are provided**, which are horizontally mounted in brush holders on opposite sides of the shaft end plate. During the portions of the armature rotation when high tension current is being delivered, each of the two slipring segments will be in contact with one of the brushes. One brush is connected to the inner distributor by means of a conducting bar similar to that used on single-spark magnetos, the second slipring brush is connected to the outer distributor by means of a short length of cable passing around the magnets. The rotating distributor piece is of double length and carries two brushes insulated from each other.

The four and six-cylinder types are fitted with eight and twelve distributor outlets respectively, each pair of outlets being connected to the spark plugs of the proper cylinder by the usual cables.

Path of the current is as follows (see figs. 6 and 7, chart 138.) Armature, secondary circuit, slipring segment and brush, one distributor, one spark plug; the metal of the engine to the second spark plug, the second distributor, the second slipring brush and segment, and so back to the armature secondary circuit.

Advance and retard: The use of two-spark ignition permits the ignition lead to be cut down anywhere from 30 to 50 percent. It will be understood that if the timing is correct for two-spark ignition, and one of the series of spark plugs is cut out of action, the remaining series will operate considerably in retard of what it would if the engine were timed for single-spark ignition.

If two-spark ignition provides the full advance, the effect of retarding the spark is obtained by cutting out one series of plugs.

The switch provided for the two-spark independent magnetos, is so arranged that ignition may be secured either with both sets of spark plugs, or with but one set. The purpose of this is to give the effect of retarding the spark, without altering the relation between the interrupter opening and the armature, as is done under normal conditions.

The connections should be so made, that the system of plugs that is operative when the switch is thrown to the single position, is located near the inlet valve.

In starting—throw switch lever to "single plug" position—this gives the effect of a retarded spark.

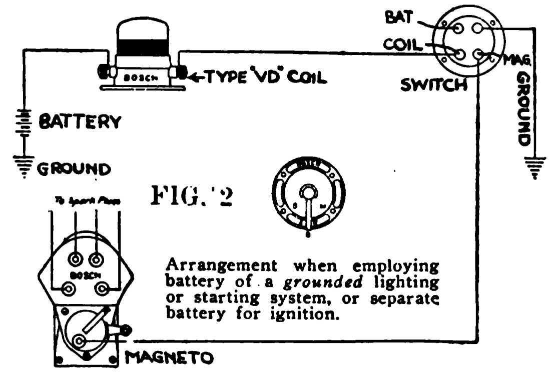


FIG. 2

Arrangement when employing battery of a *grounded* lighting or starting system, or separate battery for ignition.

The Bosch vibrating duplex system. Designed to permit easy starting on cars that are cranked by a starting motor at such a low speed that the ignition current from the ordinary magneto is insufficient to give certain ignition.

How it operates: The arrangement is such that, while the magneto circuit is absolutely independent and complete in itself, the battery circuit includes both the coil and the magneto. With the switch in the battery position, the battery and coil are in series wih the primary winding of the magneto armature, and the current from the battery supplements that generated by the magneto. Thus there is induced in the secondary winding of the magneto armature, a very powerful sparking current, which, on account of the vibrator action of the coil, appears not as a single spark, but as a series of intense sparks that will act with certainty on any explosive mixture. The sparking current so produced is distributed in the usual way by the magneto distributor.

After starting, the magneto is used. In case the starting motor failed to work, this system would be an advantage.

For ordinary running, operation should be on both series of plugs; for slow work through traffic, or when the engine is running idle, use the single plugs, or only one set.

Timing: The piston of (say No. 1 cylinder), is brought to top dead center, on the compression stroke, and the crank shaft is maintained in that position. The magneto is attached to its base with its driving gear or coupling loose on the armature shaft and the spark control placed in the fully retarded position. The armature is then turned in the proper direction of rotation, until the magneto interrupter contacts are just about to separate, at which point gear or coupling is secured to armature shaft.

It will frequently be found by experience, that this timing gives too great a spark advance, in which case, the magneto must be re-timed to operate later in the stroke. The exact timing can be secured only by experiment.

As a general thing, it will be found that the best advance for two-spark ignition, is from one-third to one-half of the advance required for single-spark ignition.

To replace a single-spark magneto with a two-spark instrument, the maximum advance for the single-spark magneto is to be marked—preferably on the flywheel—and the two-spark magneto timed so that the interrupter opens the circuit, at a point midway between the mark on the flywheel indicating the single-spark advance, and that indicating top dead center. A more exact timing may then be secured by experiment.

CHART NO. 137—The Bosch "Two-Spark" Magneto Ignition System. Bosch Vibrating Duplex System.

The "Two-spark" system regular equipment on Stutz and Mercer. Also been used on some FIAT, Locomobile and Marmon cars. See also, page 926 for Berling two-spark magneto.

FIG 1

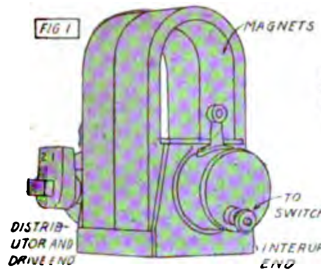


FIG 2

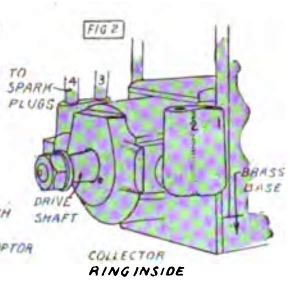


FIG 3

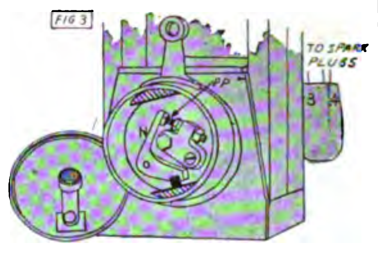
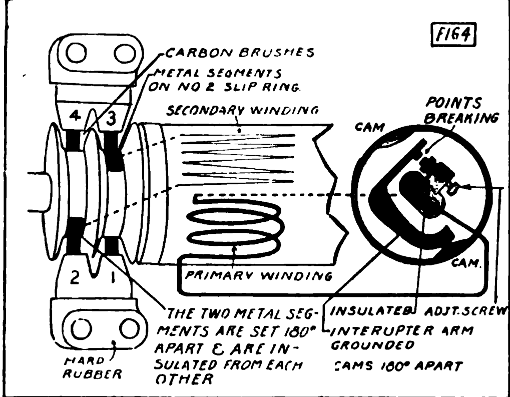


FIG 4



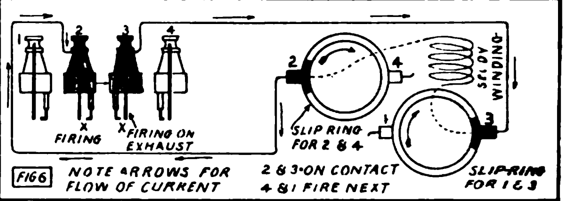


FIG 6 NOTE ARROWS FOR FLOW OF CURRENT

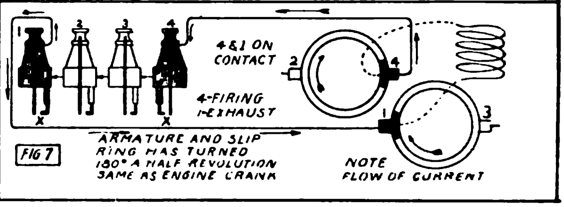
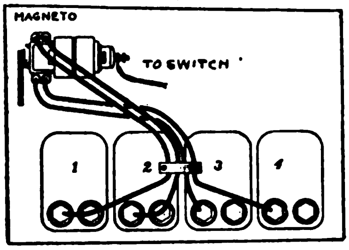


FIG 7 ARMATURE AND SLIP RING HAS TURNED 180° A HALF REVOLUTION SAME AS ENGINE CRANK



The type "NU4" Bosch magneto differs from the usual type of magneto in that the distinct gear driven distributor, common to other types, had been eliminated, and in its stead is a double slipring combining the functions of current collector and distributor. Otherwise it is about the same as any other form of magneto.

The spark occurs in two cylinders at one time with this system, but one of the cylinders in which the spark occurs is on exhaust stroke, therefore the spark does no harm.

The interrupter contacts in the full retard position should open not later than top dead center of the compression stroke; therefore the effective spark is produced in the cylinder always toward the end of the compression stroke and the surplus spark will always occur near the end of the exhaust stroke and never during the inlet stroke. In any four-cylinder, four-cycle engine, regardless of firing order, when cylinder No. 1 is nearing the end of the compression stroke, cylinder No. 4 is nearing the end of the exhaust stroke and vice versa; similar conditions apply also to cylinder Nos. 2 and 3.

The brushes, when making contact with the metal strip in collector rings, collect the high tension current and carry it to the spark plugs. Note the connections from ring to plugs. When brushes 2 and 3 are making contact—follow the circuit in fig. 6, and note the arrow points. Now if the piston makes another stroke or 180° travel, the armature will turn 180° or half a revolution also, as it runs at engine speed in four cylinder, four cycle engine, therefore the contact on ring will turn 180° or half revolution and cylinders 4 and 1 will fire as in fig. 7. This type of magneto was used on the Overland and is now used on other cars.

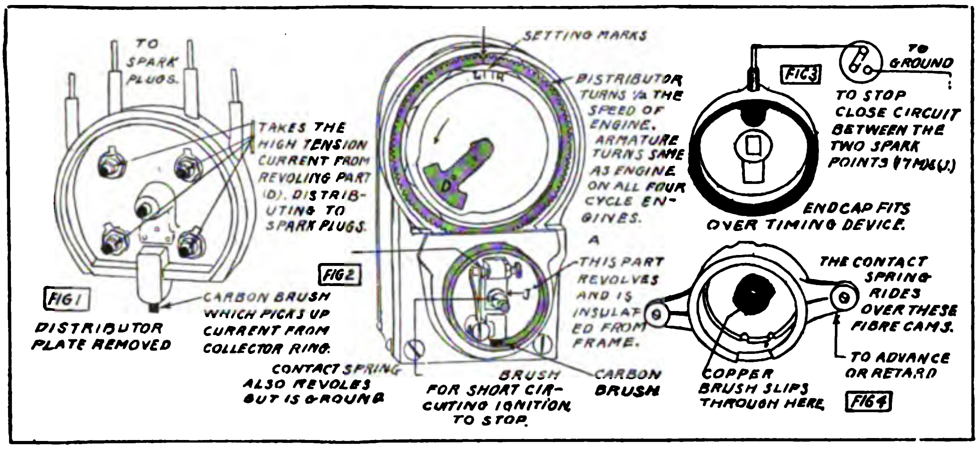
Timing the "NU4" magneto: With the average engine, this result is obtained by connecting the magneto so that **its interrupter housing is in full retard position, and the platinum interrupter screws just about to separate, when the piston of No. 1 cylinder is exactly on top dead center of the compression stroke.**

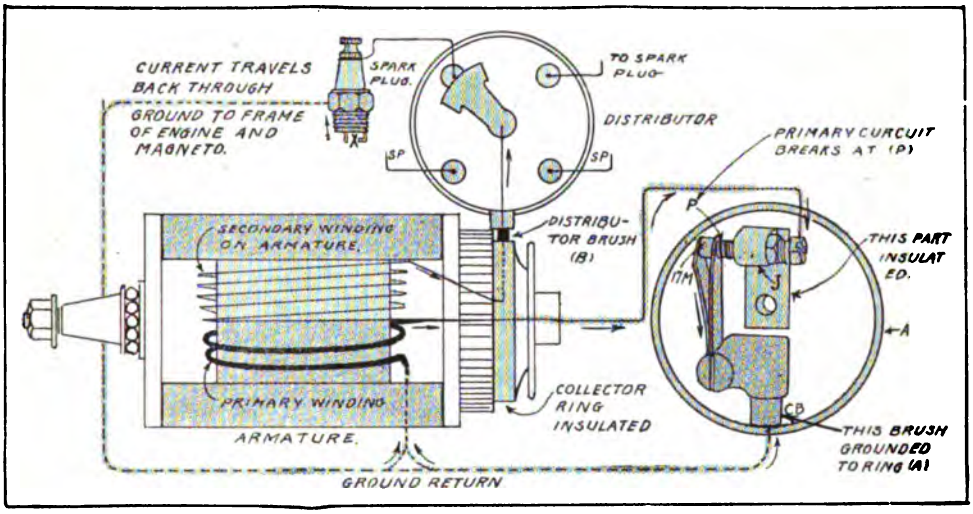
At the same time the metal segments of the slip-ring should be in contact with the brush marked "1" in each of the brush holders, and this can be observed by removing one of the holders.

The installation is completed by connecting one of the brushes marked "1" with cylinder No. 1, and the other with cylinder No. 4, and the two remaining brushes, marked "2 and 3," with cylinders Nos. 2 and 3.

It is important to note that the type "NU4," driven, as it should be, at engine speed, produces a surplus spark in each cylinder exactly 360° behind the effective or power spark and, in coupling the magneto to the engine, it must be timed so that the surplus spark occurs during the exhaust stroke and not after the inlet valve has commenced to open.

CHART NO. 138—The Bosch Type "NU4" High Tension Magneto; a "Two-Point" System; two sparks occurring at the same time, but in different cylinders.


TO SPARK PLUGS.
TAKES THE HIGH TENSION CURRENT FROM REVOLVING PART (D). DISTRIBUTING TO SPARK PLUGS.
FIG 1
DISTRIBUTOR PLATE REMOVED
CARBON BRUSH WHICH PICKS UP CURRENT FROM COLLECTOR RING.
FIG 2
CONTACT SPRING ALSO REVOLES BUT IS GROUND
SETTING MARKS
D
DISTRIBUTOR TURNS ½ THE SPEED OF ENGINE. ARMATURE TURNS SAME AS ENGINE ON ALL FOUR CYCLE ENGINES.
A
THIS PART REVOLVES AND IS INSULATED FROM FRAME.
J
BRUSH FOR SHORT CIRCUTING IGNITION TO STOP.
CARBON BRUSH
FIG 3
TO GROUND
TO STOP CLOSE CIRCUIT BETWEEN THE TWO SPARK POINTS (17M&J.)
ENDCAP FITS OVER TIMING DEVICE.
THE CONTACT SPRING RIDES OVER THESE FIBRE CAMS.
TO ADVANCE OR RETARD
COPPER BRUSH SLIPS THROUGH HERE.
FIG 4


CURRENT TRAVELS BACK THROUGH GROUND TO FRAME OF ENGINE AND MAGNETO.
SPARK PLUG.
TO SPARK PLUG
DISTRIBUTOR
SP
SP
PRIMARY CURCUIT BREAKS AT (P)
P
SECONDARY WINDING ON ARMATURE.
DISTRIBUTOR BRUSH (B)
THIS PART INSULATED.
17M
J
A
PRIMARY WINDING
ARMATURE.
COLLECTOR RING INSULATED
CB
THIS BRUSH GROUNDED TO RING (A)
GROUND RETURN

The Eisemann "G4" type of high tension magneto differs from other Eisemann types in that the make and break or interrupter mechanism is constructed on different lines. The platinum contact springs (17M), connect with a carbon brush (CB), which revolves in a brass ring (A). Ring (A) is stationary, whereas the spring (17M) revolves with the other contact plate (J). Contact plate (J) is insulated from (17M). One end connects with primary winding on armature, therefore when contact is interrupted by (17M), and point on screw in plate (J)—the spark is given as usual. The ring (A) and (17M) are grounded.

The points of (17M) and screw on plate (J) are separated by the timing device, Fig. 4, which goes over the ring (A). Contact spring rides over the fibre cams.

The novel features of this system, besides the breaker, are—its accessible and efficient grouping of the working elements all at one end and its waterproof qualities.

To set the time of spark: Place piston of No. 1 cylinder on top of compression stroke. Set the interrupter points to break in full retarded position.

Adjustments: The breaker gaps should be set .012" and spark plugs gaps $\frac{1}{64}$" to $\frac{1}{32}$".

To stop or cut off ignition: On all magnetos the magneto is stopped generating by short circuiting the primary circuit—not by **opening** the circuit as in a coil system.

CHART NO. 189—Eisemann "G4" Type of High Tension Magneto, used on the Nash, Federal an other Trucks. (Eisemann Magneto Co., Bush Terminal, N. Y.)

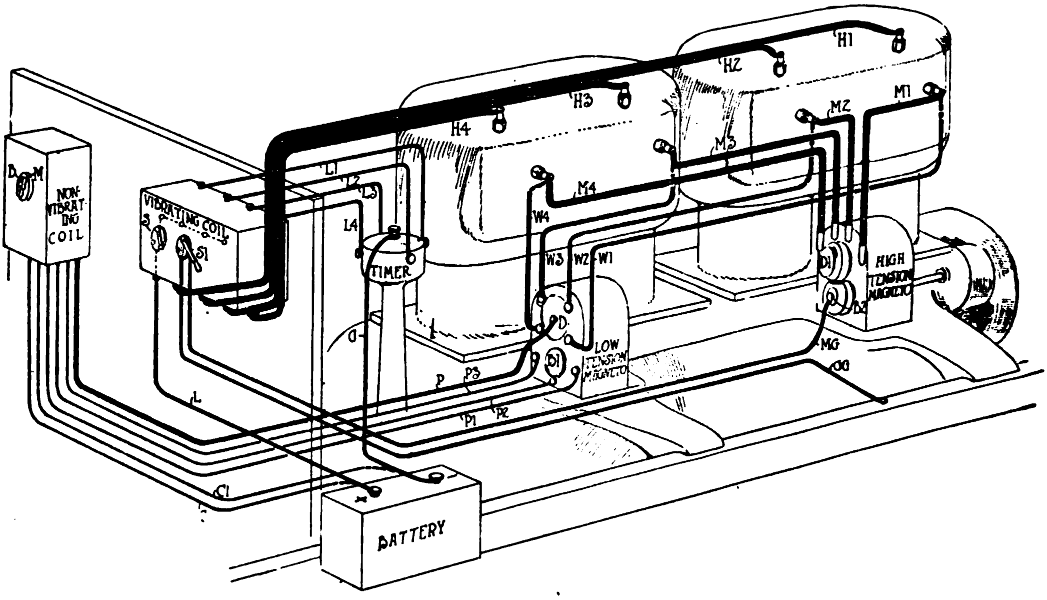


Fig. 1.—Four High Tension Ignition Systems Connected to one Four Cylinder Engine. Only two systems are usually placed on an engine, and then, only one system is used at the time. The idea is merely to show how the various systems can be combined into "Dual" or "Double" Ignition Systems.

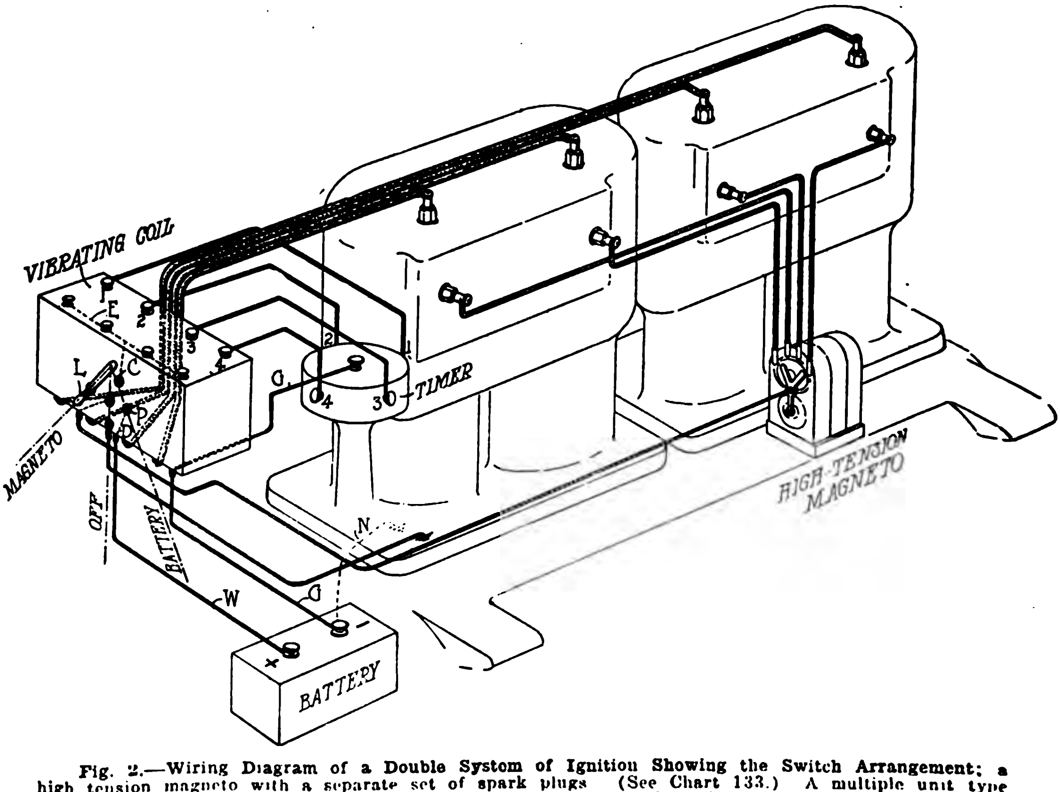


Fig. 2.—Wiring Diagram of a Double System of Ignition Showing the Switch Arrangement; a high tension magneto with a separate set of spark plugs (See Chart 133.) A multiple unit type of vibrator coil with commutator and battery and a separate set of spark plugs.
(Trace circuits with pencil.)

CHART NO. 140—Four High Tension Ignition Systems Mounted on One Four Cylinder Engine to Explain the Combination of Systems.

See foot note bottom of page 281 which refers to fig. 1.

—continued from page 279.

This style of magneto, owing to the fact that it is rocked from side to side, gives an unlimited range of advance, and thus adds wonderfully to the flexibility of the car on which it is mounted. This great range of advance makes this instrument especially suitable for **two-cycle engines, which require a much greater degree of advance and retard than the four-cycle type.** See page 289 for description.

Magneto; Automatic Advance.

The Eisemann automatic advance of spark; with all magnetos treated up to the present time, the advance and retarding of the time of spark is accomplished by hand, called "manual" advance, by means of spark lever on the steering wheel. With the Eisemann automatic advance, the same thing is accomplished by a governor arrangement automatically. This type of magneto is extensively used on commercial cars. (see chart 143 for description.)

"Combining" the High Tension Magneto and Coil and Battery System into "Dual" and "Double" Systems.

We have now explained the different leading low and high tension ignition systems for firing the charge of gas in the gasoline engine. In order to more clearly explain the four leading systems of high tension ignition, we will now place the four **ignition systems** (high tension) on one four-cylinder engine. (Fig. 1, chart 140.)

This system of using four ignition systems on one four-cylinder engine is not in actual use, but is intended to make the combination of "dual" and "double" systems clear to the reader—showing how they can be combined.

We will first explain each system separately, showing how each individual system would be connected.

FIRST: The "single" high tension magnete system—(See page 268): By referring to fig. 1, chart 140, we will put our pencil on the switch on dash coil box (S1). If this lever is thrown to the left with all other switches "off," this high tension magneto system will supply current for sparking the lower set of spark plugs (M1, M2, M3, M4). Note these wires run from the distributor on the magneto.

SECOND: The high tension coil, battery and commutator system:—See chart 140): If switch (S) is thrown to the left, the four high tension vibrating coils will spark the plugs (H1 to H4). The battery, of either storage or dry cells, usually storage, will supply the electric current in this instance. The timer, operated from one of the cam shafts through a system of bevel gears, will control the time of spark in each cylinder. (The timer is a regular type of commutator, as shown in chart 108.)

THIRD: A non-vibrating single high tension coil with battery, using the circuit breaker on the low tension magneto as the timer, and the distributor on the magneto to distribute the current to the spark plugs: —(See chart 123): If switch on the non-vibrating coil is on B, the battery will supply the electric current, passing through the primary winding of the non-vibrating coil. The circuit breaker (B1) on the low tension magneto will take the place of timer and vibrator (current does not pass through armature winding, however). The secondary current from the coil will be distributed to the spark plugs (W1 to W4), through the distributor (D) on the low tension magneto.

FOURTH: Low tension magneto and separate high tension coil:—(See charts 140 and 123): If the switch is on "M" on the non-vibrating coil, the low tension magneto will pass its current through this non-vibrating coil, increase it to high pressure and then distribute the high tension current through the distributor (D) to the spark plugs (W1 to W4), the circuit breaker opening and closing the primary circuit of magneto.

Combining into Dual Systems.

If we were to combine the last two systems, which is frequently done, we would have TWO SYSTEMS OF IGNITION using ONE set of spark plugs—but only one system sparking the plugs at the time.

The single-non-vibrating coil and battery would be used to start on by throwing the switch to (B) and after engine was started then by throwing switch to (M), the low tension magneto would take the place of the battery.

Another dual system: Vibrating coil with switch (S1), storage battery and commutator (timer), with secondary wires, H1 to H4, connected to the spark plugs, M1 to M4, in connection with the high tension magneto, connected to the same spark plugs, would give another form of dual system.

Combining into Double Systems.

The vibrating coil, timer and battery with spark plugs H1 to H4, would constitute one independent system. The high tension magneto with its spark plugs M1 to M4, would constitute the other. This would be called a double system.

Another double system, could be formed by using the low tension magneto and separate non-vibrating coil and spark plugs M1 to M4. The vibrating coil, timer and battery with spark plugs H1 to H4 would constitute the other system.

There are many methods employed to combine the different ignition systems into dual and double systems.

The Modern Battery and Coil Ignition System.

Is the system of taking the current from a storage battery, passing it through the primary winding of a high tension coil; using a combination of timer and distributor to make and break the primary current and distribute secondary current to the spark plugs. Such a system is the Delco, Connecticut, Atwater-Kent, etc. See index.

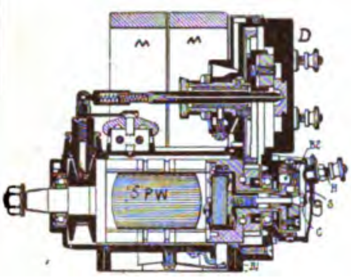


Fig. 1.—The Bosch high tension magneto. Armature revolves. The Simms, Eisemann and other types are similar.

M—magnets. D—distributor. PW—primary winding. Over this winding is (S) the secondary winding. H—is terminal which connects with switch.

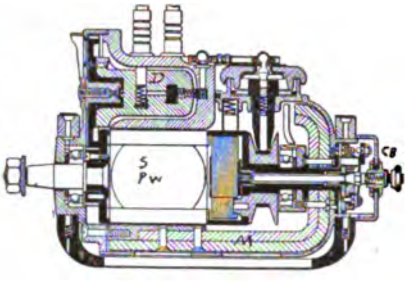


Fig. 2.—The Mea high tension magneto. Pivoting type. Revolving armature.

Note the armature is double wound, shuttle revolving type.

Instead of shifting the interrupter housing, in order to advance or retard; the field magnets are shifted.

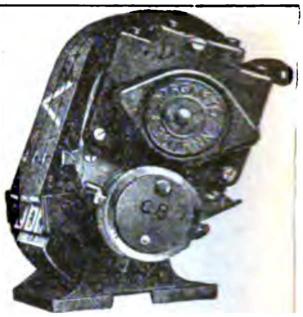


Fig. 3.—The Eisemann high tension magneto, pivoting or rocking advance magneto. The advance and retard is obtained by rocking the magneto bodily on its cradle. Otherwise the magneto is the same as other magnetos. Armature revolves.

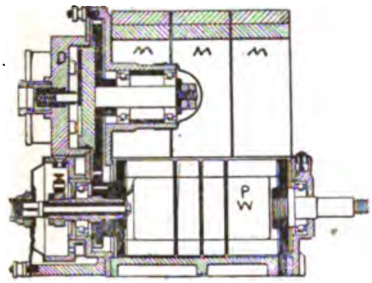


Fig. 4.—The Splitdorf low tension magneto. Armature is primary wound. Armature revolves and is of the "armature" type.

A separate high tension coil, called a transformer, must be used with this magneto.

The Splitdorf Co. also manufacture a high tension type magneto. see chart 143A and insert.

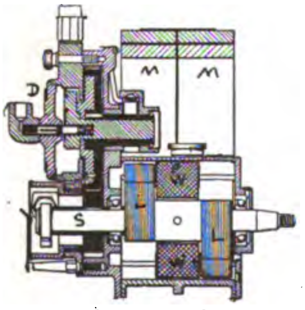
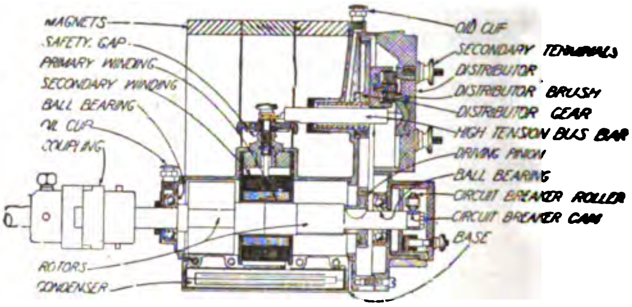


Fig. 5.—The Remy low tension magneto armature is primary wound—only one winding. Armature of the "inductor" type.

Armature does not revolve. The winding (W) is stationary and rotating magnets (L) revolve.

Separate high tension coil (called a transformer) must be used with this magneto.

The breaker gaps are set .025 in. apart.



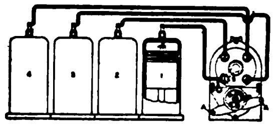


Fig. 7.—Wiring of K. W. high tension magneto.

Fig. 6.—The K. W. high tension magneto with an inductor type armature: There are two windings on this type; a primary and a secondary. The windings are stationary however, and the inductor rotors revolve. The principle of inductor type magnetos was explained in charts 120 and 126. The same principle applies here, with the exception that the two windings obviate the necessity of a separate high tension coil, as it is here provided for in the secondary winding of the stationary coil winding. By referring to index, "impulse and waves of current" and also chart 120, you will note that the K. W. gives four waves or impulses per revolution—however, either one, two, or four sparks per revolution. can be obtained by using a single or a double cam.

On the K. W. there are four sparks per revolution, with a two point cam, therefore, magneto would be driven at crank shaft speed, for an 8 cylinder engine, and 1½ times crank shaft speed for a 12.

The setting of the inductor type armature is similar to the setting of any other type. The fact of its having 2 inductors, and they being placed crosswise, is a bit confusing, but in the setting, only one is taken into consideration, and is therefore as simple to set as the ordinary type. The breaker gap points, are set to 1-64 inch.

*See also pages 256, 296 and 832 on K. W. magnetos.

Address of Magneto Manufacturers.

In writing, state where you saw the address.

Berling-Ericsson Mfg. Co., Buffalo, N. Y.
Bosch Magneto Co., 223 W. 46th St., New York City, N. Y.
Connecticut Telephone & Electric Co., Meriden, Conn.
Eisemann Magneto Co., The Bush Terminal, Brooklyn, New York.
Heinze Electric Co., Lowell, Mass.
K. W. Ignition Co., Cleveland, Ohio.
Mea Magneto; Marburg Bros., New York.
Motsinger Device Mfg. Co., 815 Market St., Lafayette, Indiana.
National Coil Co., Cedar St., Lansing, Michigan.
Remy Electric Co., Anderson, Indiana.
Simms Magneto Co., East Orange, New Jersey.
Splitdorf Electrical Co.. Newark. New Jersey.
Westinghouse Electric & Mfg. Co., Pittsburg, Pa.

CHART NO. 141—Examples of High Tension Magnetos; Also Low Tension Types. See charts 229 to 232, "Specifications of Leading Cars" for users of different makes of Magnetos.

Magneto Repairing: A. L. Dyke, St. Louis, Mo. is prepared to do expert work on magnetos or coils of all makes.

The U. S. A. motorcycle eng… runs at twice crank shaft speed.

…ns at half crank shaft speed. Generator mounted on other side

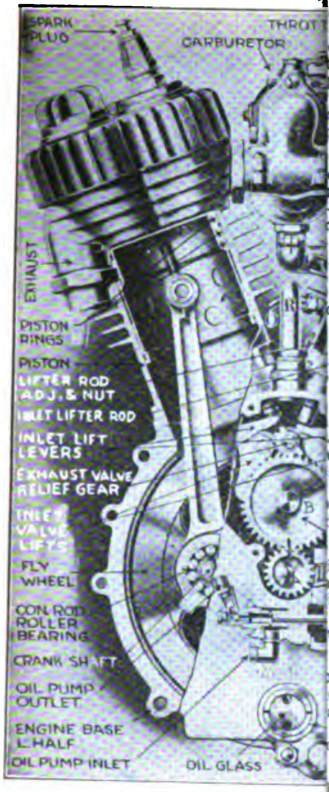


Fig. 1.

INDIAN MOTORC

Cylinders: Twin—V-type 42° apa… 3 11/32" stroke with a piston displ… H. P., normal rating is 7. Actual… of connecting rods and main crank… ler'' type; **rings**, there are 3 to …

Carburetor, Schebler, see page 8… sion magneto. Spark plugs are S… **lubrication**, oil pump worm gear d…

Valves are the side valve type o… **timing**, the valve timing is corre… are placed so that the marks regist… is keyed on its shaft and retained…

Inlet valve action can be understoo…

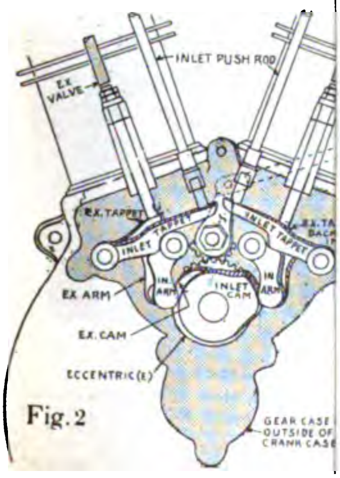


Fig. 2

ote
B1
on-
to
gs:
on
nce
1
ote
re
—if
1
w,
A)
a
to
ore
or
2
re,
0°
alf
nk
rk
re-
in-
1°
der
ine
ine
or
ual
om-
on.
are
to
one
but
in-
ge,
de.
ce-
ust
gle
15.

Allow .004" clearance between inlet and rocker arm and valve stem on all models. On 1916 and 1915 twin engines, allow .004" for rear cylinder and .006" for front and on 1917 and 1918 twin engines, allow .008" to .010" for both cylinders.

Valve timing, twin and single cylinder engines; use 6" scale (graduated 1/32"). Remove engine. Measure from head of piston through cylinder plug opening (P), fig. 14. **Exhaust valve** should start to open 3/4" to 9/16" before bottom center; closes 1/32" to 3/32" after top. **Inlet valves** do not require independent timing. Be careful to not use wrong cam in timing, small cam is for front cylinder and large for rear. Inlet valves start to open 3/16" before top and close 1/8 to 3/8" past bottom center.

When fitting new gears they are lined up as per marks shown in fig. 13, so that the marks come in line with line (J). A is crank shaft gear. B, cam gear.

Exhaust compression relief is for same purpose as explained under Indian, which is to relieve compression in cylinder for easy starting by opening exhaust valve. **When starting**, left hand handle bar grip is twisted to left, which retards ignition and further turning raises exhaust valve through rod (G, fig. 13), which raises exhaust valve through cams 1 and 3, fig. 15. The exhaust valve ports must open 1/16 to 3/32" when front piston is on top center. Time of this valve lift can be determined at point where valve lifter (1) operates valve.

Crank case compression relief; a vent (I), fig. 13, relieves pressure in crank case at every revolution. The gear (F) operates a rotary relief valve which should open 1/16 to 3/32" when front piston is on top. This valve port opens gradually when engine is turned in direction it runs and closes when piston has reached bottom. This allows a vacuum on upward stroke, to draw oil and oil vapor to all bearings. This crank case relief valve connects with vent or breather (I) in which connection there is a check valve. A pipe leads from (I) to chain cover and as it emits a slight amount of oil at each revolution, the chain is oiled.

Oiling system; oil enters from oil reservoir through pipe connection (H), it is then carried by a rotary valve pump geared to shaft F, fig. 15, through view of sight glass (V) into engine crank case. **Too much oil**—remove screw (X), if oil does not overflow, turn engine until it does. Replace (X). Then remove plunger chamber vent screw (Y) until oil flows in same manner. Then regulate oil supply by placing three .010" washers on the adjusting screw (Z, fig. 13). Drain engine and fill with 1½ pumpfulls of oil with hand pump. **To increase oil supply** add thin washers at a time. To decrease, remove washers. When all washers are removed oil pump plunger has no stroke at all.

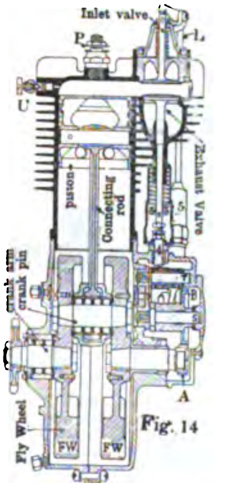


Fig. 14

Timing ignition; all twin engines, magneto equipped fire ¼ to 5/16" before top of compression stroke with spark lever advanced full and spark occurs when points are just separating.

All twin electrically equipped engines fire 7/32 to 9/32" before top. All single cylinder engines fire 3/16 to ¼".

Berling magneto, lower cam on interrupter times for front cylinder and upper cam for rear; **Dixie magneto**, No. 2 cam for front No. 1 cam for rear. **Bosch magneto**, interrupter shoe No. 2 for front and No. 1 for rear. **Remy generator interrupter**, small cam for front and large cam for rear.

See page 843 for Remy system, page 845 for carburetion.

(Harley-Davidson Co., Milwaukee, Wiscn., Mnfgrs.)

Fig. 13; side view of H.-D. engine. **Fig. 14**; sectional view. **Fig. 15**; top section view of gears and cams. 1—exhaust relief cam; 3—cam on arm of rod G, fig. 13, which operates relief cam; EC, exhaust cam; IC, inlet cam; 2—rollers on rocker arm; S, cam shaft; B, cam

o field
o that
when
nagnet
, coin-
t to a
rength
tation.
s over
greater
period.
egrees.
nes of
mag-
driving
shaft
uld be
ded if
urning
mature
shaft
in the
open.
mag-
agneto
d line
engine
suring
stroke.
two.
cables,
g the
mag-
anced.
agneto
as the
on an
ck is
shaft,
square
links,
links
readed
ore, is
tes it
works
e cage
vanced
which
arma-
e mo-
ion of
works
By
is de-
ic ad-
e ob-
n 18
es.
nser;
ights;
gnets;
ntrol

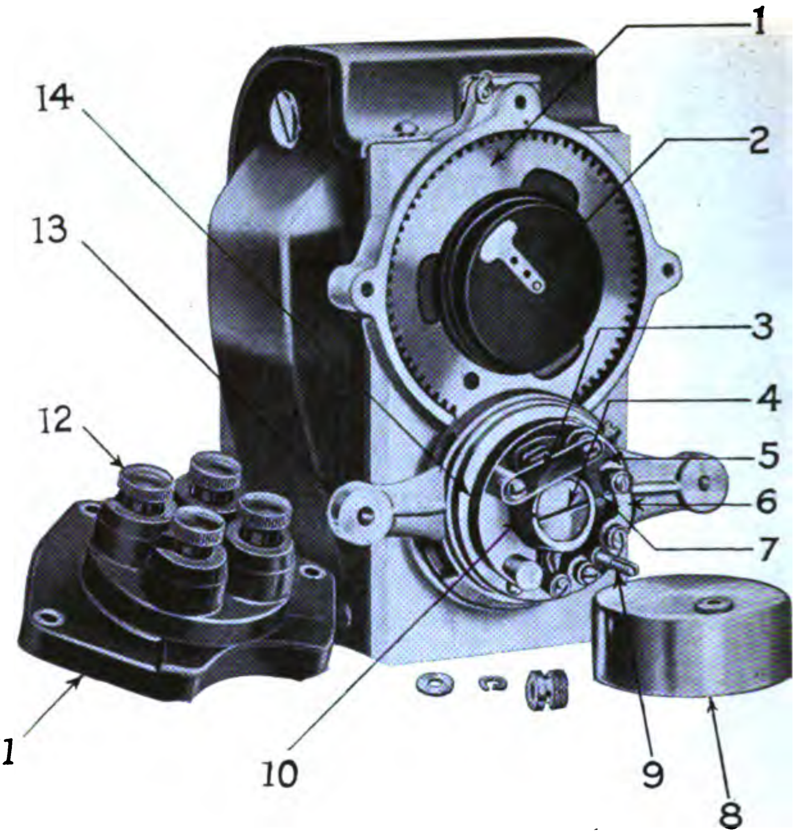
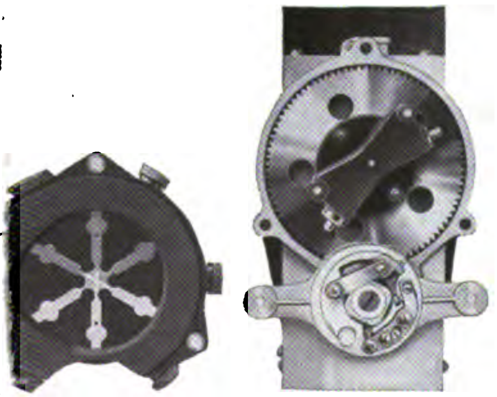


Fig. 40: Front view of parts of Dixie Magneto (4 cylinder).

ributor gear.
ributor disc.
er spring for breaker bar.
screw.
ker bar with platinum
t.
6. Contact screw bracket with insulation bushings.
7. Platinum contact screw.
8. Breaker box cover.
9. Grounding stud or terminal post.
10. Cam.
11. Distributor block.
12. Thumb nut for distributor block.
13. Breaker advance and retard lever.
14. Breaker bar spring.

ntact breaker box is permanently attached to the pole structure or part (fig. 32), which carries the condenser. When moving breaker to retard or advance, the entire parts (fig. 30) 1, 3, 24, 22, 21, 4, 18, 12 move with it, also shown in fig. 17, page 292.



—Front view of Dixie model 120—12 cyl. magneto. tributor to left and distributor rotor and gear which l behind it and which drives distributor rotor and driven from a gear on rotating pole shaft. Note distributor rotor is arranged different from (2) fig. 40—4 cyl. rotor.

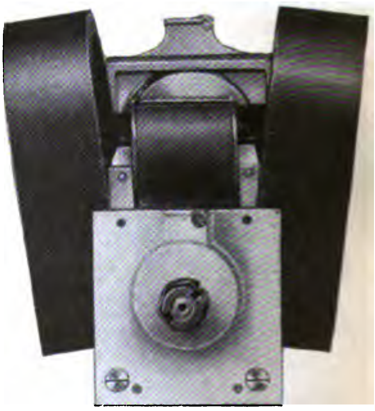
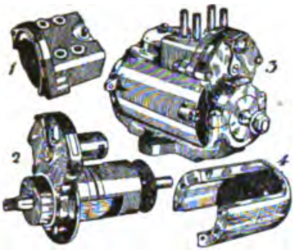


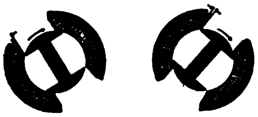
Fig. 35—Rear view of magneto—note by taking out 4 screws the winding coil (23) and condenser (1), fig. 30—can be removed. The magnets (2, fig. 30), are exposed and removed when taking off cover.

and 922 for Dixie 8 and 12 cyl. magneto.

Mea Magneto.



. ea magneto: 1. Cover. 2. Armature and distributor unit. 3. Complete machine. 4. Movable bell-shaped field magnet.



Relative positions of pole pieces and armature in fully advanced and retarded position, showing that the "maximum position" is not altered.

In the "Mea" magneto the design is such that the magneto field can be moved round simultaneously with the contact breaker so that the armature is always in the same position relative to the field when the break occurs. This is effected by having a bell-shaped magnet mounted horizontally, the axis of the armature and the magnet coinciding. As the contact breaker is moved so also is the magnet to a similar amount, and the result is that the spark is of ample strength at the retarded position even allowing for the slow speed of rotation.

This bell-shaped magnet, it is claimed, has some other advantages over the ordinary U-shaped magnet, inasmuch that it can hold a greater amount of magnetism and retain it at full strength for a longer period. The range of advance and retardation on this magneto is 40 degrees. The armature and distributor are made practically on the lines of the standard magneto with fixed magnets.

Timing the "Mea" magneto: Unless the timing of the magneto can easily be changed by advancing or retarding the gear driving the magneto, the coupling should not be keyed to the tapered shaft before the magneto is first placed on the engine, but it should be clamped on so that the timing may still be somewhat modified if found desirable.

Place the magneto in the position of its maximum retard by turning the magneto housing or timing lever in the direction of the armature rotation. Remove cover from breaker box and turn armature shaft in direction of rotation until No. 1 appears on the indicator in the front plate of the magneto, and until contact breaker begins to open.

With the dual type magneto, remove the cover over the battery breaker (driven end of mag-) and the number of the cylinder firing can be seen opposite the red line on the magneto .ing. Turn armature of magneto until No. 1 on the distributor gear is opposite the red line on housing and until magneto breaker (not battery breaker) just begins to open. Then turn engine to dead center of cylinder No. 1, and if of the 4-cylinder type, about 1½ inches beyond, measuring on the circumference of the fly wheel, or from 1-16 inch to 3-32 inch downward on the explosion stroke. With 6-cylinder engines, it is preferable to time fullretard only slightly beyond dead center.

After the magneto and engine has thus been set, effect a positive connection between the two. Of course contact hole No. 1 of the distributor is connected with cylinder No. 1 by means of cables, and so on until all the cylinders are properly connected.

With the Mea, the engine should be started with spark fully retarded and by increasing the speed gradually it can readily be determined if the engine will stand all the advance which the magneto can furnish with the original setting, or whether the whole timing can be further advanced. After it has been assured that the best timing is obtained, the coupling should be keyed to the magneto shaft.

Eisemann Automatic Spark Control Magneto.

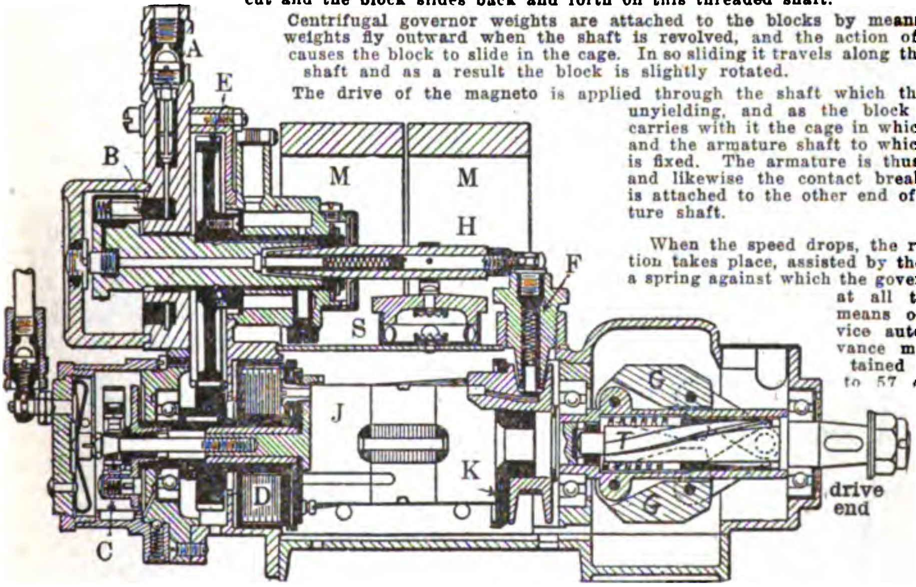
Construction of the Eisemann automatic spark control magneto is of the same construction as the standard high tension magneto with the addition of the automatic mechanism.

As for the details of the method by which the automatic timing is obtained; a cage is mounted on an extension of the armature shaft, and a rectangular block slides in this cage. This block is drilled and threaded for the reception of a helically-cut shaft (T). This shaft is the driving shaft, which is attached to the gearing. It has a thick, double thread which is square cut and the block slides back and forth on this threaded shaft.

Centrifugal governor weights are attached to the blocks by means of links, weights fly outward when the shaft is revolved, and the action of the links causes the block to slide in the cage. In so sliding it travels along the threaded shaft and as a result the block is slightly rotated.

The drive of the magneto is applied through the shaft which therefore, is unyielding, and as the block rotates it carries with it the cage in which it works and the armature shaft to which the cage is fixed. The armature is thus advanced and likewise the contact breaker, which is attached to the other end of the armature shaft.

When the speed drops, the reverse motion takes place, assisted by the action of a spring against which the governor works at all times. By means of this device automatic advance may be obtained from 18 to 57 degrees.



A—terminal to spark plug from distributor; B—distributor brush; C—contact-breaker; D—condenser; E—distributor gear on distributor to lower gear on armature; F—collector brush; G—governor weights; H—high tension current conductor; J—armature; K—collector spool at end of armature; M—magnets; S—safety spark gap; T—spiral thread for spark advancing by centrifugal force action.

CHART NO. 143—The Mea Pivoting Type of Magneto. The Eisemann Automatic Spark Control type of Magneto.

(Chart 142 omitted by error in numbering.)

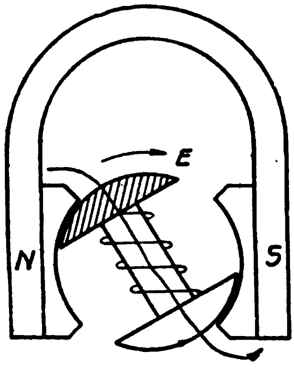


Fig. 1.

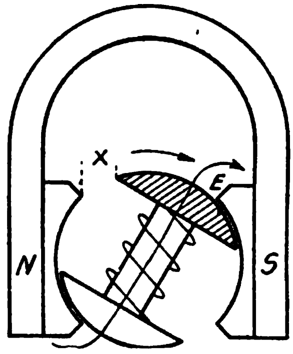


Fig. 2.

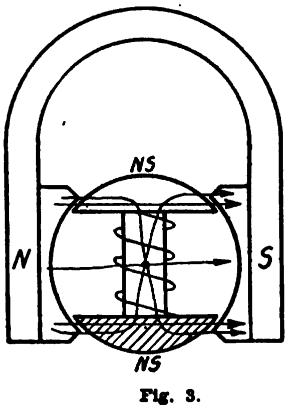


Fig. 3.

Dixie Compared to the *"Armature" Type Magneto.

The large number of magnetos commercially in use prior to the advent of the Dixie were of the *armature type, therefore used for comparison.

An "armature" type magneto is shown in fig. 1. The magnetic lines of force hereinafter referred to as flux lines flow from the N to the S pole of the U-shaped magnet through the revolving armature in the direction indicated by the arrow. The shaded end E of the armature is shown in the figure as being under the influence of the N pole of the magnet.

In fig. 2, the armature has revolved to the right sufficiently for the end E to come under the influence of the S pole of the magnet. Immediately the direction of the flux lines is reversed through the armature as shown by the arrow, and at this instant current is generated in the winding about the armature, the spark taking place. In practice, more than one winding is employed, also an interrupter and a condenser, but the function of these parts need not be referred to here, it being the purpose to now show only the differences in the operation of the magnetic circuit of the two types.

Now it is obvious that the mass of iron in the armature must reverse its magnetic polarity. In fig. 1, it is saturated with magnetism flowing in one direction. In fig. 2, the direction is reversed. This reversal must take place in each rotation, so at high speeds the quicker the iron reverses the better the spark. As a laminated armature, or one built up of a number of pieces of iron, reverses quicker than a solid one, all good armatures are laminated. But it is also evident that to secure the desired amount of current the armature must be of a certain size to contain the necessary wire, and therefore contains a certain amount of iron in some form. Now, the more iron beyond a certain limit the slower the reversal, also the reversal is not as abrupt.

Fig. 3 shows the "neutral" position of the armature wherein it is subject to flux flowing across through its ends as shown. This position does not permit of an abrupt change of flux flow as hereafter described and such as occurs in the Dixie. The armature is never completely out of the flux, but simply turns around in the flux stream, twisting the lines about, but not actually abruptly breaking them.

Dixie Principle.

The Mason principle, on which the Dixie operates is shown in fig. 4. The magnet has two rotating polar extremities N S, which are always of the same polarity, never reversing. These poles are in practical contact with the inner cheeks of the permanent magnet M, all air gaps being eliminated. Together with the U-shaped magnet, they form a magnet with rotating ends.

Positioned at right angle to the rotating poles or ends of a field structure consisting of laminated pole pieces F and G (fig. 5) carrying across their top the laminated core C carrying the windings W. When N is opposite G, the flux flows from one pole N of the magnet to G and through the core C to F, this action corresponding to what happens in the armature type with the armature in the position shown in fig. 1.

In fig. 6, the pole N has moved over to F and the direction of the flow of flux is reversed, it now flowing from F through C to G.

Fig. 7 represents the rotating poles occupying a midway position between that shown in figs. 5 and 6. Here the field pieces F and G are magnetically short-circuited, as it were, thereby completely scavenging stray lines of flux out of the core C. Compare this with the uncertain corresponding action that takes place in the armature type, when the armature is in the same position, fig. 3.

Now the first great difference between the Dixie and the "armature" type is in the fact that the rotating poles in the Dixie do not reverse their polarity at any time, consequently the lag due to the magnetic reluctance in this part is eliminated. This partly accounts for the high efficiency of the Dixie at low speeds, for motorcycles and high speed engines. In the Dixie, the windings are actually never in the field. The flux is shot through them, as described, producing a hot "snappy" spark of peculiar and highly efficient igniting power, owing to the quick break and absolute reversal of the flux at each revolution.

With the armature type machine, it is the central core or part actually enclosed by the winding that is laminated, as the ends adjacent the windings must be solid. In the Dixie type, not only the core C, around which the wire is wound, is laminated, but also the pole shoes G and F, consequently all parts of magneto subject to reversal of flux are "laminated."

The armature type magneto (fig. 8) has a rotating element carrying windings, a laminated core, a condenser, collector ring, etc.

The Dixie rotating element, or armature construction, consists of two pieces of cast iron (N&S) fig. 9, and a brass block (B) placed between them. There are no rotating wires. Figs. 10 and 4, shows more clearly how they are positioned between the poles of the magnets. On the 4 and 6 cylinder magneto, there are 2—N & S—poles and on the 8 and 12 cylinder magneto there are 4, see fig. 31 (insert).

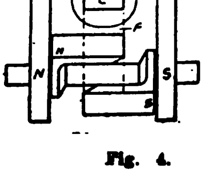


Fig. 4.

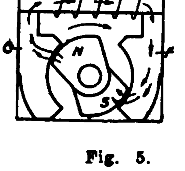


Fig. 5.

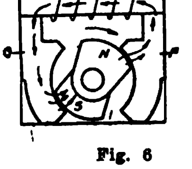


Fig. 6

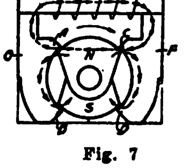


Fig. 7

The generating winding (W—fig. 4) in the Dixie is carried on a small coil (23, fig. 30–insert) placed across the upwardly projecting ends of the two pole pieces (figs. 32 and 35—insert)—see also fig. 4, (C).

HART NO. 148A—The Dixie High Tension Magneto. Above matter taken from manufacturers escription. Splitdorf Co., Newark, N. J.

See page 274, explanation of "armature" type magneto.

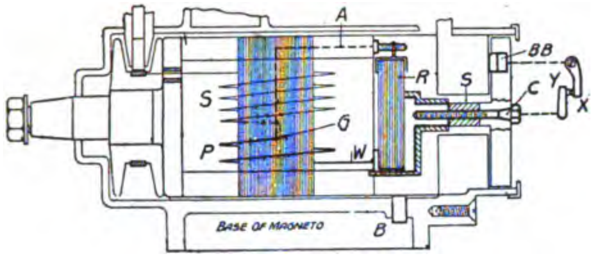


Fig. 8—*Armature type magneto armature.

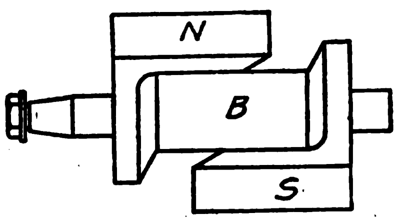


Fig. 9—Rotating element in Dixie.

Comparison of Primary Circuits.

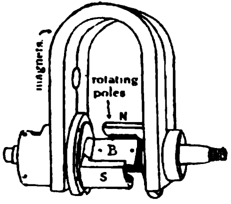


Fig. 10—Showing how the rotating poles (fig. 9) are placed between magnets of Dixie magneto.

Fig. 8 shows the usual primary circuit in the armature type machine, and fig. 12 the same circuit in the Dixie. A, fig. 8, denotes the revolving armature on which is wound the primary winding P and secondary S. Grounding brushes B and BB are necessary to insure a good contact between the grounded end G of the primary and the breaker point X, the latter being positioned in the breaker mechanism which is movable for timing purposes. It will be seen that the free end W of the primary connects to the condenser R, and attention is called to the fact that this condenser is built into the armature and revolves with it, and the armature must be disassembled to get it out. The shaft S is made hollow and a bolt C is carefully insulated where it passes through the same, this bolt connecting the free end of the primary and condenser to the insulated point Y of the breaker which revolves as a unit with the armature.

In the Dixie the core of the coil A, fig. 12, is stationary, and the inner end G of the primary winding P is grounded on the core. Q indicates the metal frame of the machine, which is put together with screws, so there are no brushes or sliding contacts, therefore brushes B, BB, fig. 8, are eliminated.

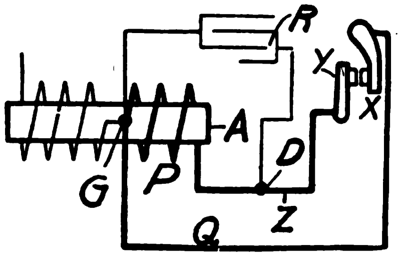


Fig. 12—Simple primary circuit of Dixie. No brushes or contacts except breaker points.

The brush B is necessary in the armature type to insure a good circuit from the revolving armature to the frame of the magneto and thence to the engine.

The condenser R in the Dixie is positioned immediately above the coil and is readily removable, it being only necessary to take out two screws. This condenser does not revolve as in the armature type. The terminal D is a screw on the head of the coil and the wire Z connects to the contact Y of the breaker.

High Tension Circuit.

Fig. 15 (below)—High tension circuit in "armature-type" magneto.

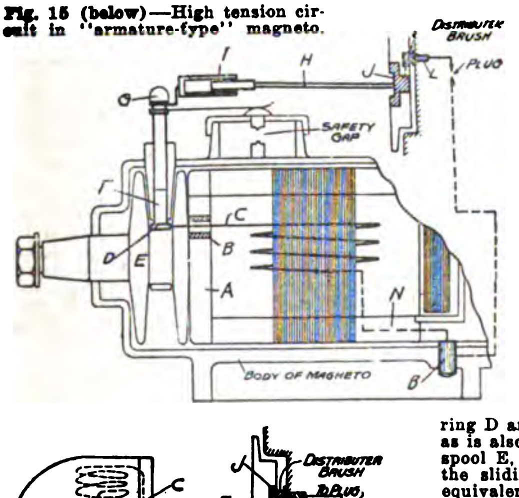


Fig. 15 shows the **high tension circuit in the armature type machine.** In the metal armature head A is the insulating bushing B, through which the free end C of the high tension winding passes. This connects to a metal ring D carried on the rubber spool E. A brush F engages the ring and carries current to the terminal G, which in turn supports one end of connector H, which has a sliding portion I, so it can be removed. The outer end of H connects at J to the traveling contact of the distributor, which in turn contacts on the segment L, to which is connected the spark plug cable. It will be understood that the high tension circuit is completed from the frame of the armature N through brush B to the frame of the magneto and to the engine and spark plug.

Fig. 16 shows the **Dixie high tension circuit.** Here the end C of the high tension winding goes to a metal plate D carried on the rubber side A of the coil. Against D bears a connection F, which is practically one piece with the traveling contact J, which connects to the spark plug segment L, the circuit being completed through the spark plug, engine frame and frame of magneto in the usual manner without brush G. The first difference to be noted in the Dixie construction is that the secondary winding being stationary, the spool E, the revolving ring D and the brush F bearing thereon are entirely eliminated, as is also all their troubles, such as punctured insulation in the spool E, wear of the brush F, collection of oil on D, etc., and the sliding connection I and member H are eliminated, their equivalent being a steel point F turning in contact with the plate D.

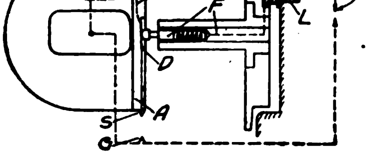


Fig. 16—High tension circuit of Dixie magneto. Note direct path from spool to distributor. No revolving contacts except at distributor.

Safety Gap.

An efficient safety gap arrangement is provided by the point S arranged in proximity to the framework indicated at G, fig. 16. Width of gap should be 5⁄16 to 3⁄8". **For high compression engines** set 3⁄8". Under high compression, the sparks may fire across the safety gap instead of firing in the engine. Missing under such conditions can easily be remedied by opening the safety gap so that it will offer a **greater resistance** to the secondary current than the spark plug gap, under compression. Sparks should not be permitted to discharge across the safety gap for any length of time.

CHART NO. 143B—The Dixie Magneto—continued.

*See page 274 meaning of "armature-type" magneto.

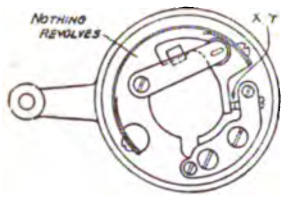


Fig. 13—Breaker (or interrupter) of Dixie magneto. A cam (fig. 17) opens the points by raising end of arm. The cam is the only part of breaker mechanism which revolves. See (10), fig. 40, of insert.

Dixie Breaker and Interrupter.

Contacts are stationary and do not revolve as in the "armature" **type.** See fig. 13 and compare it with armature type figs. 1 and 2, page 298.

To adjust Dixie interrupter points (XY); this can be done while magneto is running and intensity of spark can be seen while adjusting. See fig. 33 (insert) and note screw for adjusting.

"Armature" Type Magneto Timing.

The advance and retard of a magneto is necessary to make up for the "lag" in engine operation as well as variation of speed, fuel, etc.

Setting "armature" type magneto armature to the time of break of interrupter points is usually accomplished by measuring the distance (X) fig. 2, page 290, between one of the pole pieces and adjacent edge of armature. The breaker is then adjusted so that points are just separating. This is taken as the **advanced** position of magneto, and with this setting the maximum spark is obtained.

Timing "armature" type armature with engine; the usual practice however, is to place piston on top dead center of compression stroke with breaker box fully **retarded**—with points just opening—this of course increases width of opening of X, fig. 2, with a corresponding weakening of the spark. To advance the spark, the breaker box is moved so that the points open sooner in relation to the piston, thereby obtaining best spark when running.

It is clear to see that spark will be weak at retard position, because gap (X) is wide, consequently the sudden surge of the flux line through armature has already passed its maximum.

It has therefore been customary with some armature type magnetos to use a compromise setting for the breaker in which the maximum efficiency of the machine is not utilized at full advance setting on the engine. This compromise setting permits a mechanical advance in such magnetos of approximately 30 degrees, but it is doubtful if in many of these machines the effective range exceeds 12 or 15 degrees, as the maximum spark of the magneto is never utilized.

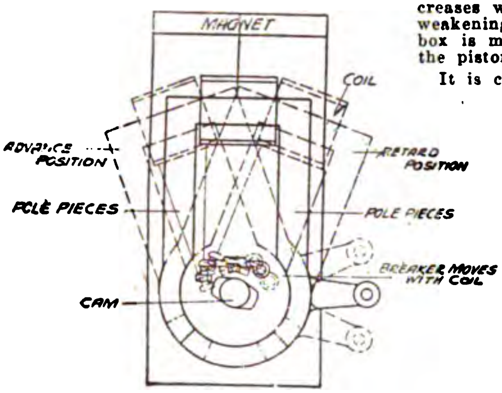


Fig. 17—Shows breaker and housing which when retarded or advanced—moves the coil structure with which it is attached, giving same intensity of spark at full advance or retard.

***Fig. 36: A simple method of synchronizing the position of rotor with time of opening of breaker points,** is explained in foot note below and shown in illustration fig. 36. Contact points should separate .020 when opened by cam.

Fig. 37: The breaker housing is adjustable. Being screwed to coil carrying structure it can be moved in same direction as cam operates—if rotor gap is too small. If too large, rotate in opposite direction (to adjust for wear of fibre bumper also).

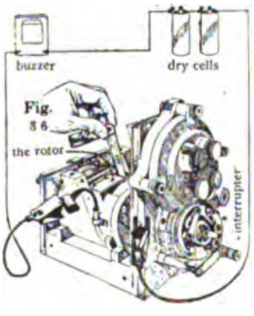
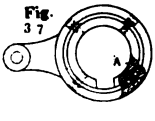


Fig. 37



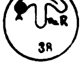


Fig. 38: Correct position of distributor brush in contact with segment (A) when breaker is fully advanced. Correct position prevents back firing and tail burning of distributor segment.

Dixie Timing.

The advance and retard of Dixie magneto is obtained by shifting the breaker box, but note in **fig.** 17—that it is attached to the "coil structure" (C-F-G, figs. 4 to 7). Therefore the breaker **housing** and coil structure are **all advanced or retarded at the same time.** See figs. 30 and 32 (insert) **which** will probably make this clearer. An absolute advance of 30 degrees or more is obtained by **simply** rotating the coil carrying structure to which **the** breaker box is attached, around the axis of **the** rotating poles N S, figs. 4 to 7 and 17.

Setting Dixie armature or "rotor" to breaker points; the distance X, fig. 2, page 290 (armature type illustration used to explain Dixie)—**is usually** .020 inch just as points are breaking. The **maximum** rate of change of flux occurs in this **position** of rotor (X, fig. 2)—where rotor wings have **just** reversed the direction of the flux through the **core.**

To facilitate this setting of the relation **between** rotor and separation of contact points—**a buzzer** can be used as shown in fig. 36. The **most effective** distance for X is never varied on the **Dixie.**

To position breaker or interrupter box so that points open at desired point—note that the **breaker** housing (fig. 37, this page) can be moved by means of set screws (11)—fig. 30 (insert)—**around** the cam, so that the break can be made to **occur** without interfering with adjustment of **points.**

To time Dixie magneto to engine: (1)—place piston on top of compression stroke; (2)—uncouple magneto; **(3)**—place breaker in retarded **position;** **(4)**—rotate driving shaft of magneto in **direction it** is driven until platinum points are about to **separate.** **(5)**—couple magneto; **(6)**—connect distributor **terminals** as explained on page 296.

Above timing is for the 4 and 8 cylinder magnetos, also 1 and 2 (twin cylinder motorcycle type (M1 and M2); also Dixie model 11 and 21.

On the 8 cylinder, the distributor brush (A2—fig 19, **page** 293) should be in contact with No. 1 **terminal** of distributor block—see **figs.** 22 and 23, page 293.

To time 6 cylinder, model "60" magneto—place piston $1/16$ of an inch ahead of the end of the **compression** stroke with timing lever in full retarded position and breaker points just separating. **Distributor** terminal is connected with No. 1 plug terminal.

To time 12 cylinder, model "120" magneto: place piston $5/16$ of an inch ahead of the end of **compression** stroke. With breaker or timing lever retarded, turn magneto drive shaft direction of **rotation** until carbon brush A2—fig. 20, page 293 is in contact with segment connected with terminal No. 1 **of** distributor block fig. 26, and 24 and 25, page 293. When points are about to separate—couple **magneto.** See under figs. 24 and 25, page 293 for **distributor** connections.

Cams on 4 and 6 cylinder interrupters have 2 lobes; 8 and 12 cylinder, 4 lobes.

HART NO. 143C—The Dixie Magneto—continued.

*If a buzzer is connected as shown, it will be in circuit with contact-breaker points. While contact **points** closed buzzer will operate. Turn armature slowly (direction rotation) until instant buzzer ceases—**just at**

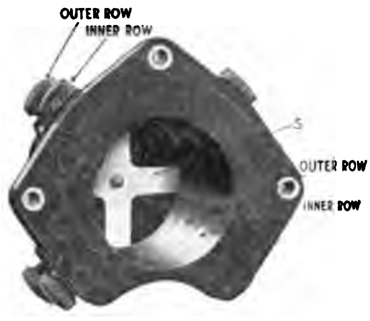


Fig. 19—8 cylinder distributor. Note there are two rows of segments.

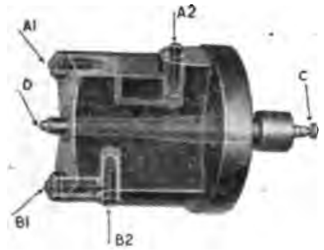


Fig. 20 — The "rotor" of the 8-cylinder distributor (also 12).

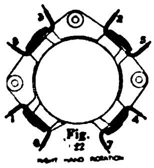


Fig. 22 RIGHT HAND ROTATION

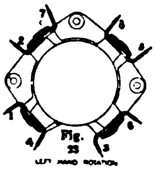


Fig. 23 LEFT HAND ROTATION

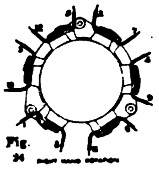


Fig. 24 RIGHT HAND ROTATION

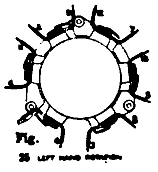


Fig. 25 LEFT HAND ROTATION

Figs. 22 and 23, show order of sparks delivered by 8-cylinder distributor.

Figs. 24 and 25, order of sparks of 12-cylinder distributor.

Terminals on 24 and 25 are marked 1R—12R for right hand rotation and 1L—12L for magnetos left hand rotation.

Therefore, (right hand rotation) connect cable from terminal 1R to spark plug No. 1 cylinder; cable from 2R to spark plug next in sequence of firing and so on.

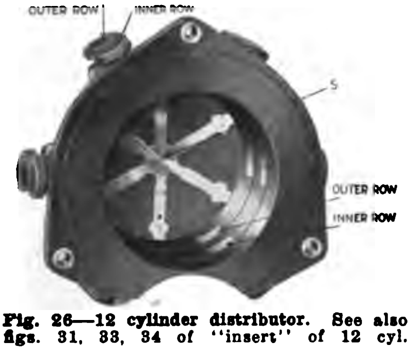


Fig. 26—12 cylinder distributor. See also figs. 31, 33, 34 of "insert" of 12 cyl. magneto.

Dixie Eight Cylinder Distributor.

Four sparks are produced during each revolution of the drive shaft, at the instant of the "break" from the edge of the field structure. There are 4 rotating poles to the 8 and 12 cylinder magneto as per fig. 31, (insert). On the 4 and 6 cylinder magneto there are two.

Magneto is driven at crank shaft speed, because 8 cyl. 4 cycle engines fire 4 cylinders per revolution—this 8 cyl. magneto generates 4 sparks per revolution. As firing of cylinders take place at cam shaft speed, the distributor is geared down 2 to 1 of armature shaft.

Distributor—On the 4 and 6 cylinder magneto the segments are placed in one row proper distance apart. On the 8 cylinder magneto there are two 4 cylinder distributors (fig. 19), placed side by side, but moulded together, and having a double "finger" or **rotor** (fig. 20). **Contacts** are so arranged that one segment in each row is alternately in contact. Rotor itself is hard rubber.

The high tension current is collected by brush C, fig. 20, which is in contact with the high tension winding (see fig. 16, page 291), and conducted through the center of the "finger" or rotor, to brush (D), thence by means of a metal sector, S, fig. 19, moulded in the hard rubber block, the current is conducted to either of two sets brushes A1-A2, B1-B2, fig. 20, in the wings of the distributor rotor.

These brushes arranged in sets, become alive alternately at the moment when they are actually in contact with a segment in either of the two rows of four segments in the block making it impossible for the spark to jump to the wrong segment as in this manner a spark received at any post in the inner row of the block will be followed by a spark from a post in the outer row but 180° away.

Dixie Twelve Cylinder Distributor.

Four sparks are produced each revolution of drive shaft of magneto. There are four rotating poles same as on the 8.

Six cylinders must be fired per revolutions of crank shaft—therefore magneto will turn 1½ revolutions to 1 of crank shaft and distributor is geared 3 to 1 of armature shaft.

Distributor is two six cylinder distributors moulded together as per fig. 26. Note sector (S) in fig. 26, how it differs from 8 cyl. sector (S), fig. 19. **The "rotor"** of the 12 is similar in construction as fig. 20.

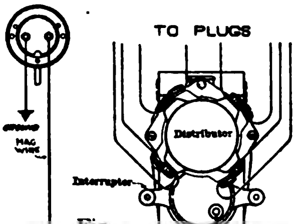


Fig. 27

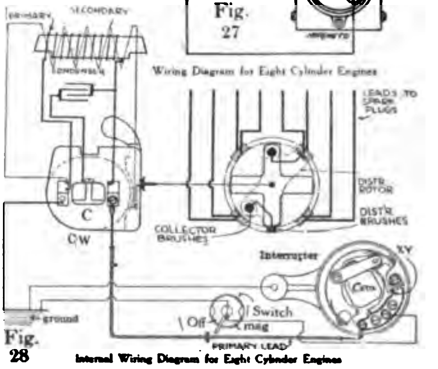
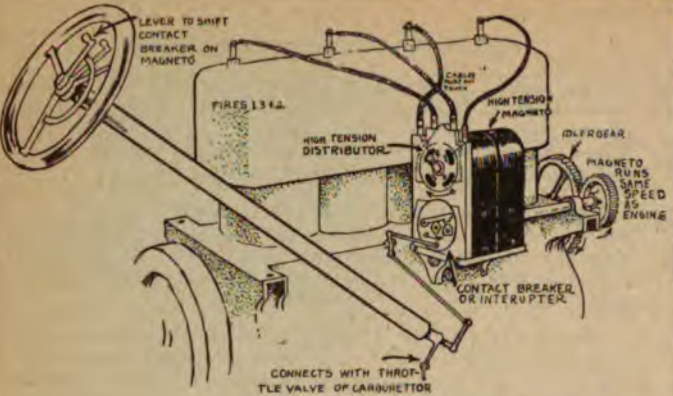


Fig. 28 Internal Wiring Diagram for Eight Cylinder Engines

See figs. 16 and 12, page 291—which will assist in making this diagram clear. Note— (CW) in fig. 28 is the coil winding and connections—above it is the internal wiring as an explanation, see also pages 918, 922.

CHART NO. 143D—The Distributor and Rotor of Dixie 8 and 12 Cylinder Magneto.


LEVER TO SHIFT CONTACT BREAKER ON MAGNETO
FIRES 1 3 4 2
CABLES
HIGH TENSION MAGNETO
HIGH TENSION DISTRIBUTOR
IDLER GEAR
MAGNETO RUNS SAME SPEED AS ENGINE
CONTACT BREAKER OR INTERUPTER
CONNECTS WITH THROTTLE VALVE OF CARBURETTOR ON OTHER SIDE OF ENGINE.

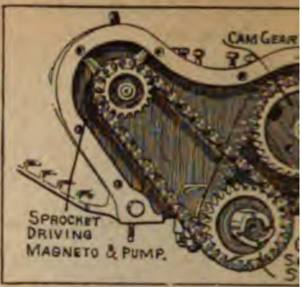


Fig. 2. The silent chai
method on a six cylinder
(gears are also frequently us
six). Note sprocket driving
is slightly larger, therefore
sprocket will turn 1½ revolu
one revolution of crank shaft

Magneto Drive.

The magneto can be driven by gears or chain, but must not be driven by belt or friction,
the armature must be set in a certain position in relation to the time of spark. A belt woul

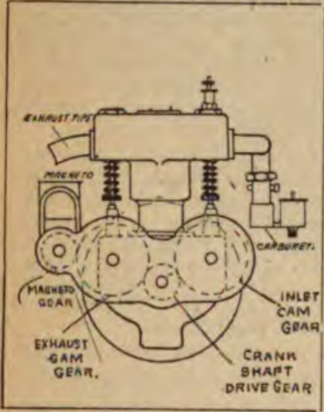
The method for advancing and retarding the time of spark, is usually by means of a rod connect
end with the spark lever on th
ing wheel, the other end conne
the bell crank, thence by a ro
interrupter or breaker box ho

By shifting this housing in
direction of rotation of cam,
would raise the interrupter
interrupt the flow of current
or in "**advance.**"

By shifting this housing **wit
tion of rotation of cam,** the i
tion would occur later or "**ret**

On some types of magnetos,
Mea, chart 143, the field magn
"advanced" and "retarded"
ing the magnets bodily arou
armature (called pivoting ad

Advance which can be obta
magneto, is usually 22 to 35



No. 3: Note the ratio of gearing to magneto on a "T" head 4 cylinder engine.

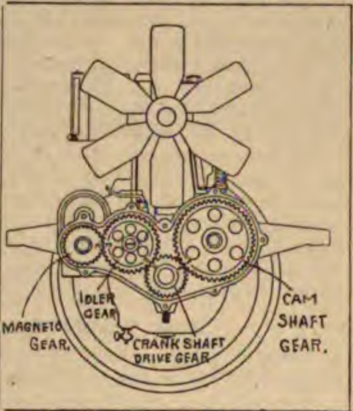


Fig. 4. Note the same ratio is used on the "L" head 4 cylinder engine.

Speed Relation.

**Speed relation of magneto a
to crank shaft:** The number
lutions of the magneto armatu
regard to the engine is as fol

(a) **Four-cycle engines:**
der engine, half the speed o
shaft; 2 and 4-cylinder engines, same speed as crank shaft; 3-cylinder engine, at ¾ speed of crank
6-cylinder engine, at 1½ speed of crank shaft; 8-cylinder engine twice, the speed of crank shaft. **A t**
cam C, fig. 5 is generally used, see also page 298

(b) **Two-cycle e**
1 and 2-cylinder
same speed as crank
3-cylinder engine,
speed of crank shaft
inder engine, twi
speed of crank sh
cylinder engine, 3 ti
speed of crank shaft

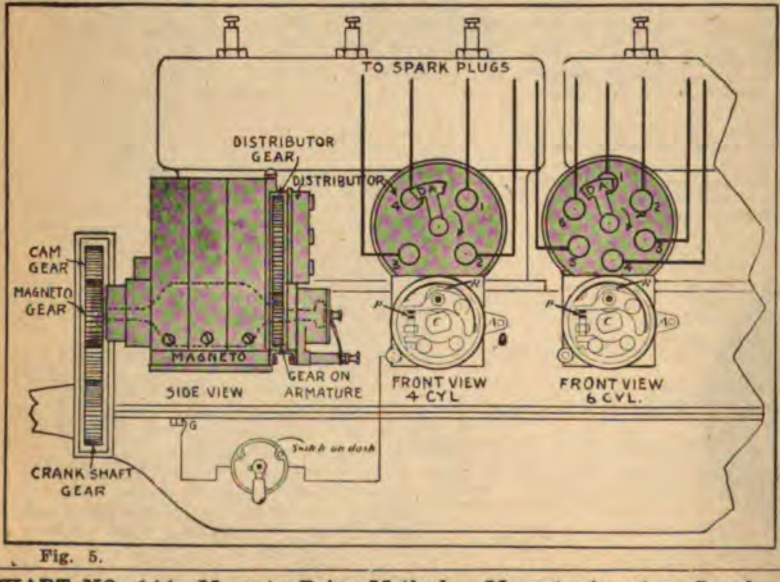


Fig. 5.

Distributor Spe

**Fig. 5. Illustrati
ratio of gearing betw
cam gear and dist
gear on the 4 and
der magneto, (four**

On a 4 cylinder
armature turns same
as crank shaft, but t
tributor, turns once
crank shaft twice.
cylinder engine, the
ture turns 1½ times
crank shaft once, or
lutions to the cran

The distributor, h
turns once to the
twice. **Distributor of
inder magneto** (see i
tion), the contact se
are 90 degrees apart
**tributor of 6 cylinde
neto,** contact segme
60 degrees apart.

CHART NO. 144—Magneto Drive Methods. Magneto Armature Speed.

INSTRUCTION No. 23.

MAGNETO INSTALLATION: Magneto Speed. Distributor Connections. Care of Magneto. Adjustments and Troubles. Interrupters; construction and care. Testing Secondary Windings. Remagnetizing Magnets. Clockwise and Anti-Clockwise Rotation.

Magneto Driving Method.

This description applies to the types of high tension magnetos with double wound armatures.

The magneto is usually placed along side of the engine (see chart 144), mounted on a separate base provided for it. The base of the magneto is usually made of brass, as brass will not become magnetized, therefore the magnetism is confined to the magnets, otherwise they would soon lose their magnetism.

†**The magneto armature shaft can be driven by gears, flexible shaft or silent chains.** Lost motion should be eliminated, and it is advisable to drive the magneto through gears with a flexible coupling, per fig. 4, page 302.

The magneto may be driven by chain and sprockets if gears cannot be fitted, but the arrangement should be such that the chain will run with as little slack as possible, and at the same time without placing undue side strains on the armature bearings.

The necessity for preventing slippage prohibits driving the magneto by belt or by friction. On silent chain drive there is usually an "idler" or some means provided to take up the slack in the chain.

The magneto must be driven at a fixed speed, because the armature must be in approximately a vertical position and interrupter point just breaking when the piston is in the correct position to receive the spark (see page 309). The correct position for the piston to receive the spark, is just an instant before it is at the end of its compression stroke.

The armature is therefore set, by meshing its drive gear in relation to the gear on the crank shaft so it will be in this position at this time.

*Magneto Speed.

A high tension magneto of standard construction produces a high tension or jump spark current; this current being generated in the windings of the magneto without the use of a separate induction coil.

Two ignition sparks are produced during each revolution of the armature in the usual type, and these are transmitted to the proper cylinders by means of the high tension distributor, which is integral with the magneto. Once during each half revolution of the armature the primary circuit is broken, and the abrupt interruption of the primary current results in the production of the high tension current in the secondary winding.

The variation in ignition timing, is effected on the magneto itself, the arrangement permitting the interruption of the primary current to occur earlier or later in the revolution.

On a four cylinder engine, four sparks are required during two revolutions of the crank shaft. The magneto gives two sparks or impulses to one revolution of its armature, therefore it would be geared to drive at the same speed as the crank shaft.

On a six cylinder engine, six sparks are required during two revolutions of the crank shaft, therefore the armature would revolve one turn, and half of another turn, making three sparks, while the crank shaft made one turn. Therefore on two revolutions of the crank shaft, the armature would make three revolutions or six sparks.

The distributor, however, on both the four and six cylinder engine, would revolve one-half the speed of crank shaft. As the distributor brush would make one revolution, to two revolutions of the crank shaft. See fig. 5, chart 144.

****A two-lobe cam** is generally used on the interrupter, with lobes or projections 180° or one-half revolution apart. This causes an interruption of current every half revolution of the armature—see C, page 296, also page 298.

Distributor Connections.

Before the magneto distributor can be connected with the spark plugs, the firing order of the engine should be determined, and in the case of four cylinder four cycle engines the firing order must be either 1, 3, 4, 2, or 1, 2, 4, 3, or if a six, it would probably be 1, 5, 3, 6, 2, 4, or 1, 4, 2, 6, 3, 5. The firing order may be determined by cranking the engine slowly and observing the order in which the inlet or exhaust valves operate, this order of operation being identical with the firing order.

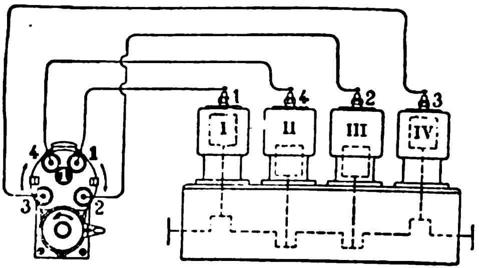
—continued on page 297.

---

*See page 294, 306 and 308.

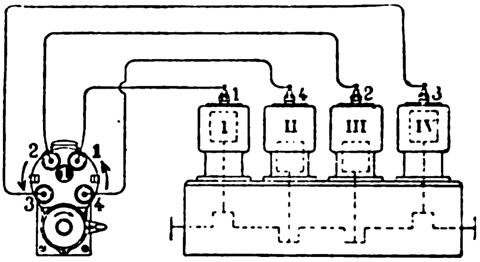
†**The best method for driving a magneto is with a flexible coupling,** per fig. 4, page 302 and page 312. The coupling and shaft is usually driven by a gear. This permits undue strain on armature, if not exactly in line and also reduces vibration to armature shaft. The chain drive is the least desirable of the three methods.

If a gear is used to drive magneto direct to a gear on armature shaft, sufficient clearance must be allowed between gear on magneto and the driving gear, in order to reduce strain on the armature shaft. **See page 922 for cams used on 8 and 12 cyl. engine magnetos.



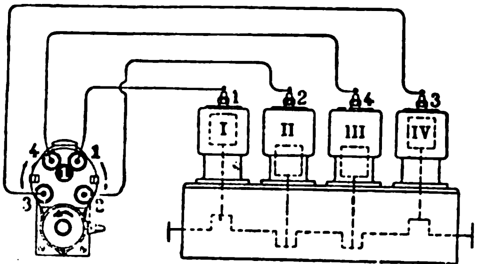
View of Distributor End

Magneto running clockwise
Firing Sequence I, III, IV, II.



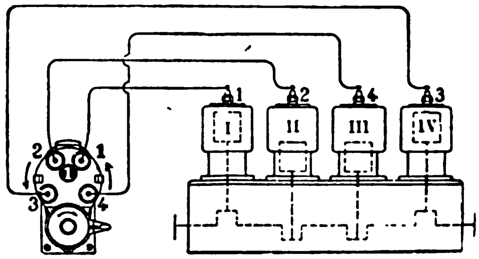
View of Distributor End

Magneto running anti-clockwise
Firing Sequence I, III, IV, II.



View of Distributor End

Magneto running clockwise
Firing Sequence I, II, IV, III.



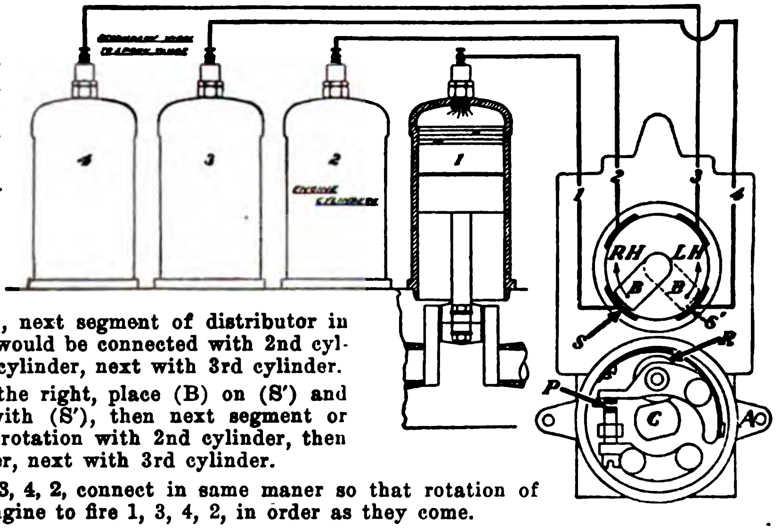
View of Distributor End

Magneto running anti-clockwise
Firing Sequence I, II, IV. III

Method of connecting the spark plugs with distributor on four-cylinder engines; when engine is firing 1, 3, 4, 2 or 1, 2, 4, 3. Also note the different method of connection when the magneto runs clockwise, and anti-clockwise. Clockwise means in the same direction as the hands of a clock move, anti-clockwise in the reverse direction. Note when armature revolves in one direction, distributor revolves in the opposite direction. This is due to the motion of the gears. In the case of a magneto the direction of rotation clockwise or anti-clockwise, is always stated viewing the magneto from its shaft or driving end.

Connecting distributor to cylinder: firing order 1, 2, 4, 3. If cam (C) turns to the left, set (B) on (S) and connect cylinder No. 1 with (S), next segment of distributor in direction of rotation would be connected with 2nd cylinder, next with 4th cylinder, next with 3rd cylinder.

If cam turns to the right, place (B) on (S') and connect cylinder 1 with (S'), then next segment or cable in direction of rotation with 2nd cylinder, then next with 4th cylinder, next with 3rd cylinder.



If engine fires 1, 3, 4, 2, connect in same maner so that rotation of brush B, will cause engine to fire 1, 3, 4, 2, in order as they come.

RH—abbreviation means arm (B) turns right hand, when cam (C) turns to the left; **LH**—abbreviation means arm (B) turns **left hand,** when cam (C) turns to the right; **P**—are platinum contact points on interrupter; **R**—is roller raised by cam (C) which causes separation of (P); **A**—is interrupter or contact breaker housing.

If cam run to left, shifting (A) down would "advance" and **up** would "retard."

The sooner cam separates (P)—**quicker the spark—(advance)**; the later the cam separates (P)—later the spark **(retard).**

Above illustration is that of the K. W. high tension magneto per page 288. Although the four-pole rotor is used, as explained on page 256—there are but four sparks delivered to engine during two revolutions of the crank shaft. The cam (C) being a two-point cam and revolving same speed as crank-shaft, results in two sparks per rev. or four sparks for two rev. The distributor revolves one rev. to crank-shaft two.

CHART NO. 145—Distributor Connections. Relative Rotation of Distributor to Interrupter Cam Clockwise and Anti-Clockwise Rotation Explained. (see also page 313.)

—continued from page 295.

There is usually a peep-hole on the distributor provided on magnetos that show which contact the distributor brush is on, for instance: When the figure 1 appears through peep-hole (see fig. 2, page 310) in the distributor disk, the distributor is making contact with terminal No. 1, and this terminal should therefore be connected to the spark plug of cylinder 1. Bearing in mind that the rotation of the distributor is opposite to the direction of rotation of the armature, the next distributor contact that will be made should be connected to the spark plug of the cylinder that is next to fire. The third and fourth terminals of the distributor should be connected to the remaining spark plugs **according to the firing order.** These connections will be facilitated by a study of the wiring diagrams in chart 145.

Note the explanation of both four cylinder firing orders are given also the meaning of the term applied to magnetos running "**clockwise**" and "**anti-clockwise.**"

A study of these illustrations, especially fig. 5, chart 144, will enable the reader to also understand the connections for a six cylinder engine. It is merely a matter of connecting the cable from distributor terminal which is next on contact, to the cylinder which fires next.

Care of the Magneto.

Distributor parts: Distributor plate should be removed occasionally for inspection as to the presence of the carbon dust that wears off the carbon brushes. This dust may form a connection between the distributor segments, and in consequence cause a spark to occur in the wrong cylinder. Carbon dust that has collected on the distributor should be wiped out with a cloth, the cloth being moistened with gasoline should the carbon have become caked. After cleaning with gasoline, the inside of the plate should be given a very light film of oil to prevent excessive wear of the brush and the distributor plate.

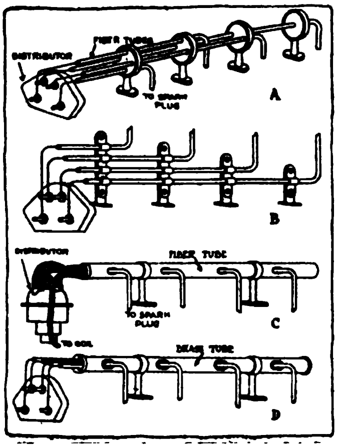


Fig. 3. A—method by which the wires can be separated from one another to avoid static effects. B—another method of separating wires to avoid static effects. C—with this arrangement static effects are sometimes felt. D—running wires through brass tubing does not avoid static effects.

****Cables.** Use only the best insulated wire for all electrical connections and especially those leading to the plugs. The wires running from the distributor to the spark plug are called **secondary cables** and should be protected from "static" electricity—see fig. 3 below. (A, B are best arrangements).

Terminals. Scrape off about 3/16 inch of the insulation from both ends of the cable, clean the copper wire and screw it into tube of terminal (it will not do to push it in only) in order to connect the two parts thoroughly. Spread out inside the tube the portion of the wire which has been stripped of its insulation and screw in the little screw supplied for the purpose.

Many a case of ignition trouble has been hard to locate due solely to one of the strands of wire short circuiting. Therefore, if special connections are provided use them, otherwise solder the ends.

*Interrupter Adjustments.

Among the most important parts of the magneto is the †interrupter (see figs. 1 and 2 illustration, chart 146); and it is advisable to inspect it from time to time. An inspection of the interrupter requires the removal of cover which is usually secured to the interrupter housing by means of a spring ring that permits it to be snapped on and off. The interrupter lever should be moved for assurance that it is free on its pivot, and a test should be made of the distance between the platinum points.

Adjustment: When the lever is depressed by one of the steel segments or cam, the distance between the platinum points should be about .015 to .020 or about 1/64 inch. This distance may usually be adjusted by the movement of a platinum pointed screw.

Should it be necessary to replace one of the platinum points or to attach a spare part, the interrupter may be more completely exposed by turning lock ring a quarter of a turn to the right or to the left and removing it and the interrupter housing. The interrupter itself may be removed by unscrewing interrupter screw.

When replacing the interrupter, care must be taken that the key on the interrupter disk

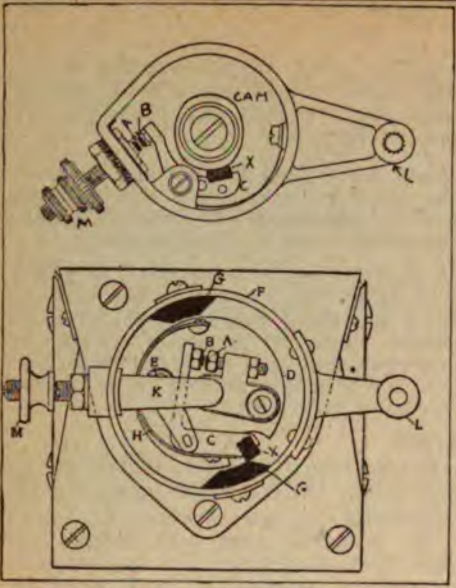
---

Static electrical discharge means jumping of high tension current from one wire to another when together, even though insulated.

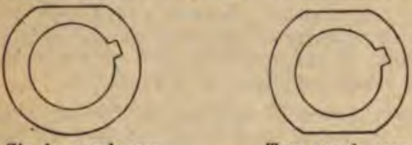
*The adjustment of the gap at the platinum contact points (see chart 146) on "contact breaker" on magneto, when separated by nose of cam, ought not to be over 1-64 of an inch, however, this is not intended for a rule to go by altogether—there is a slight variance on different makes of magnetos.

On the Bosch Z R 4 and Z R 6 magneto the space is .4 of a millimeter, as a millimeter is 1-25th part of an inch, therefore space is very small, about 1/64 in. On the Remy .020 to .025; the Splitdorf .020 of an inch. The average is from .020 to .025. **See pages 240 and 425.

†Note: S. A. E. now designate the **Interrupter** as "**Breaker-Box**"—see foot note page 298.



Figs. 1 and 2. Two types of interrupters.



Single spark cam. Two spark cam.

Fig. 9. On a single cylinder engine requiring **but one spark** during two revolutions of the **crank, a single cam is used which is attached to end of armature, which revolves ½ the speed of crank shaft. The two point cam, however, is most generally used.**

On a four cylinder engine the cam would open interrupter twice during one revolution, therefore it would run same speed as the engine, causing four openings during two revolutions—see chart No. 145.

**Magneto Interrupters.

The ****interrupter** is constructed in v forms. The principle, however, is abou same. The purpose of the interrupter is to or interrupt the flow of current in the pr winding of the magneto armature just a armature breaks from the pole cheeks (page

The interrupter on four cylinder as w the **six** cylinder engine magneto, must inte the current twice during one revolution. T fore a cam with two projections placed (half revolution) apart is provided.

If a cam is not used, then means fo complishing the same thing must be provid

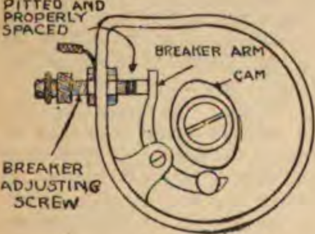
Note the arrangement in fig. 2, here we **two cam-blocks (G) stationary to the insi the interrupter housing (F) placed 180°** As the disc (D), revolves, the parts C, H, A and X revolve with it.

At the extreme end of (C) is a proj (X), when this fibre projection (X) strikes block (G), the platinum point contacts (B a are opened. (H) is a spring provided for ing the points together at other times. (K flat metal spring which connects with ter (M) and is used to carry current to grou switch—see fig. 1, chart 129.

†Interrupter adjustment: There is one a ment on the magneto which needs watching; of the platinum point breaker contact s The adjustment should be made so that the imum break of the platinum points is .015 to .020 inch, or about $\frac{1}{64}$ of an inch

***If the engine misses with the spark ret** (and misses more at low than at high sp the contact screw should be screwed out a at a time until the missing is overcome **the engine misses with the spark adv** (and more at high speed than at low), the tact screw should be screwed in a notch time until the missing is overcome. When rect adjustment is once made, further atte should not become necessary for several mo

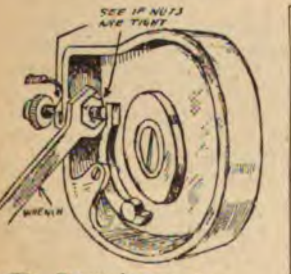
EXAMINE PLATINUM POINTS SEE IF PITTED AND PROPERLY SPACED



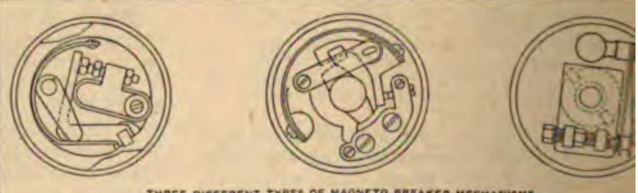
Note that the adjusting screw is very delicate and to be adjusted carefully. **If platinum points are "pitt** then they should be filed down flat with a very fine jew file. (See page 234.) **Keep oil away from the points.**

The Spark plug gaps, when used with magneto ign should be about $\frac{1}{64}$ to $\frac{1}{32}$ or about .025—see page 235

Common contact-breaker troubles are; insufficient lub tion causing wear; loose breaker bar, fibre bumper wor



The Remy interrupter.



THREE DIFFERENT TYPES OF MAGNETO BREAKER MECHANISMS

Bosch
In this the moving contact is carried on a bell crank which rotates with the armature shaft, the cams being inside the breaker box

Dixie
The cam revolves with the armature shaft operating a bell crank which remains stationary so adjustments can be made while running

Eisemann
This consists of two members separated by piece; one of the ries the moving contact The cam is stat

CHART NO. 146—Magneto Interrupters:** Construction and Care.

***Widening the gap** causes the interrupter points to open earlier, causing spark to occur when magn ture is at a more favorable position—giving a more intense spark. Closing of gap is just the r foregoing. †Usually, a small flat wrench is provided with magneto for adjusting.

****S. A. E. now designate the Interrupter as "Breaker Box."** The term "Interrupter" is used in owing to the fact that this matter was set up before the designation was adopted. In some instances t will be made.

fits exactly into the keyway on the armature shaft, and care must also be exercised when replacing the interrupter housing, being sure it is placed back in exactly the position it was taken off.

The platinum points on the interrupter "pit" in time, but not so bad as the points on a vibrator coil. The alternating current of a magneto does not cause pitting of the points as much as the direct current. However in time the points are bound to become worn and new ones must be fitted, or the old ones dressed down. (See dressing platinum points, page 234.)

The Safety Spark Gap.

In order to protect the insulation of the armature and all other parts from injury due to excessive voltage, a safety spark gap is provided to permit the passage of the current to ground without injury. The current will pass across the safety spark gap in case a high tension cable is disconnected, if the spark gap is too great, or if for any other reason the spark plug circuit is open. Discharge should not be permitted to pass through the safety spark gap for any great length of time, however. This should be particularly guarded against if the engine is operated on a second or auxiliary ignition system. When the engine is operated on such a system, the magneto should be grounded in order to prevent the production of high voltage current.

Oiling the Magneto.

The over oiling of the magneto should be guarded against in order to prevent the entrance of oil to the interrupter parts. Each of the oil holes is to be given a few drops of fine machine oil every two weeks or every 1000 miles. The interrupter is designed to work without lubrication, and the presence of oil on the platinum points will give unsatisfactory results, inasmuch as it will cause sparking at the points and possible misfiring.

Vaseline is suitable for lubricating the ball bearings, but never use oil on the interrupter whereby it will reach the platinum points.

Cutting off the Magneto Ignition.

To cut off the ignition the primary current must be "grounded," which will prevent the breaking of the circuit by the opening of the interrupter, and consequently prevent the production of the secondary current. The primary current may be grounded by making a connection between the grounding nut and the engine ground, this circuit usually including a switch. One terminal of the switch is connected to the engine or frame, the other terminal leading to grounding terminal. **When the switch is open the magneto will produce a spark, but the closing of the switch will ground the primary circuit and will prevent the production of the ignition spark.** (See fig. 5, chart 144 (switch is shown in lower part of figure) and fig. 1, page 268.)

Magneto Ignition Troubles.

In case of defective ignition it must be determined whether the fault is in the magneto or in the plugs. Generally when only one cylinder misses, the fault is in the plug.

Defects of Spark Plugs.

1st. Short-circuit at the spark gap, due to small metallic beads which are melted by the heat of the intense spark and form a conducting connection between the electrodes. This defect is easily ascertained and may be remedied by removing the metallic beads. (See page 237.)

2nd. If the gap between the spark plug electrodes (point) is too great, the spark will jump across the safety gap on the magneto. In such a case, when the plug is unscrewed from the cylinder the spark will jump across the electrodes of the plug, and not across the safety spark gap. This does not signify that the distance between the electrodes is correct for it must be borne in mind that open air has a lower resistance than the compressed air or gas existing in an engine cylinder. The distance between the electrodes when under compression in the cylinders must, therefore, be less than is required in the open air. The correct gap should be approximately $\frac{1}{64}$ to $\frac{1}{32}$".

3rd. Fouling of the plug. If fouling should occur, the parts exposed to the burning gases may very readily be cleaned by removing the plugs from the cylinder. This exposes the plug core, and it may be cleaned with gasoline.

The spark plug used with a magneto should have the point set closer than with a battery and coil ignition, because, when the magneto runs slow the current is not as strong as when running fast. With a battery as a source of supply, the current is constant at all times.

The spark plug cables must be tested, and special attention should be paid to ascertaining that the insulation is not injured in any way. The metal terminals of the cables must not come in contact with any metal parts of the engine or with any metal parts of the magneto, except the proper binding posts.

*Diagnosing Magneto Troubles.

(1). Engine balks—no spark.
(2). Misses at low speeds.
(3). Misses at high speeds.

(1). Cause of: Broken connections, short circuit in primary circuit, or between coil and distributor brush. Timing maybe wrong or breaker points too far apart.

(2). Cause of: Spark plug gaps too far apart, or too close; breaker points too far apart; loose connections or short circuits; weak magnets.

---

*See also page 301.

(3). **Cause of:** Breaker points set too close; breaker arm not working freely, loose connections or short circuit.

Ignition fails suddenly. A sudden failure of ignition indicates a short-circuit in the low tension cable, either through a defect in the cable, through a faulty connection of the switch, or through the presence of dirt or moisture. This may be tested by removing the grounding cable from binding post on the magneto and endeavoring to start the engine on the magneto. If the engine runs with this wire disconnected, but stops when the wire is connected, it may be taken for granted that there is a fault in the insulation or some other defect through which the low tension current escapes to "ground." It is also advisable to examine the carbon distributor brush to ascertain if it is in good condition. This brush may be exposed by removing distributor plate.

Irregular firing. Irregular firing is usually caused by the improper working of the interrupter, and this part should be examined. It should be seen to, that the interrupter lever moves freely on its pivot, and that the center screw is properly tightened; see also that the steel segments or cams, as well as the two platinum screws, are properly secured in position. Furthermore, the platinum points should be inspected for the correctness of their adjustment, and they should be so set that they are about 1-64 of an inch apart when the interrupter lever is depressed by one of the segments. The platinum points should be clean, flat and true to one another, and any oil, grease, or dirt that is deposited on them should be removed. If they are uneven or in bad condition—but only then—they should be trued by means of a fine flat file. If the interrupter lever does not move freely on its pivot, (as is occasionally the case, particularly with new magnetos,) the hole through the fibre bushing that forms the bearing should be reamed out. This work should be very carefully performed, however, and excessive reaming guarded against.

Starting the engine. To start engine it is sufficient to give a sudden pull to the starting handle at the moment a spark is to take place in one of the cylinders. If the engine does not start off at once this may be caused by either or all of the following:

(a) by setting not being done in a proper way; (b) by the points of the plugs being too much apart; (c) by the cables being faulty or the connections being badly made. Very often the carburetion is faulty.

In any case, care should be taken when stopping the engine to short-circuit the magneto and to cut off the supply of gasoline (by closing throttle) when the engine has ceased running. In this way the cylinders are prevented from being filled with air. If the cylinders contain gasoline, the starting of the engine is always easy. If on the contrary, the supply of gasoline (throttle) is cut off while the engine is running, the cylinders get filled with air and on restarting, it has to be driven out and replaced by gasoline.

Coil. If on turning the magneto no high tension current is produced, it may be that the coil is damaged (this applies to low tension magneto with separate coil, or the secondary winding on the high tension armature), and should be returned to the manufacturers in order to have it either repaired or replaced.

Magnets. Remagnetizing will not be necessary unless the magnets have lost their magnetism due to the fact of their having been taken off and left, for a long period, without their bases having first been bridged by a piece of iron; or else if, after having taken out the armature, no piece of iron or steel has been placed on the pole pieces. This piece of iron or steel should remain there until the armature is replaced. It often happens that on remounting the magnets, a mistake is made in placing them in the wrong order, whereby their magnetic power is completely neutralized.

When it becomes necessary to take the magneto apart you will do well to draw a chalk line across one side of all the magnets or be careful that the same marks stamped on the magnets appear all on the same side. All north poles are to be replaced on one side and all south poles on the other. See charts 148 and 149 for remagnetizing.

Difficult starting is in many cases caused by the fact, that upon stopping the engine, the supply of gasoline is cut off, while the ignition only should be stopped. In this way the cylinders are filled with air only, without any gasoline and no explosions are possible. By opening the throttle about one quarter of the way, draw in a "mixture" of air and gas then engine will start.

By cutting out the ignition only, there will be gasoline vapor in the cylinders instead of air and the engine can be set in motion by half turn of the starting handle, i. e., by a sudden pull at the moment of highest compression.

Springs. Examine from time to time whether the safety contact spring sliding in front of the cam presses sufficiently against the cam; as soon as the steel bosses are rather worn, the spring should be replaced by a new one. By putting some oil now and then upon the steel parts, too rapid wear will be prevented.

Carbon Brushes. The low tension carbon brush, as well as the high tension distributor, will wear off in the course of time and have to be replaced by new ones, i. e., in the first case as soon as the spring presses down on the metal holder of the carbon, and in the second as soon as the spring of the carbon comes out of its case.

When magneto armature rubs against pole-piece, it is likely due to worn bearings or broken ball, loose screws on armature head, or gears meshed tight causing undue wear on one end of shaft.

Synchronizing Distributor with Armature.

Synchronizing the interrupter points, cam and distributor. If magneto has been entirely disassembled proceed as follows:

Bosch DU4 as an example: (1st) place distributor brush on segment—just starting; (2nd) place armature in direction of rotation $\frac{3}{32}$ inch from pole shoe—just breaking (see fig. 2, page 313); (3rd) breaker to start opening advanced.

Bosch DU4, model 5: (1st) place brush in center of segment; (2nd) armature $\frac{1}{16}$ of an inch from pole shoe; (3rd) breaker points will start to open at full retard.

Bosch dual system: (1st) place brush $\frac{1}{16}$ inch on segment; (2nd) armature breaks from pole $\frac{1}{64}$ inch; (3rd) breaker points will separate at full advanced position.

Magneto Trouble Indications.

Failure of magneto to give the proper spark may be due to:

Armature: weak current; open primary; open secondary; shorted primary or secondary.

Condenser: short circuited; open circuit—see page 303.

High tension circuit: brush on collector spool cracked or punctured; loose connection to collector spool; defective distributor brush.

Spark plugs: improper gap; fouled—see page 304.

Magnets: weak; reversed.

Contact breaker: points worn; points too close or too far apart; weak spring—see page 304.

Assembly: gear bearing worn or dry; armature rubbing on pole pieces and end play in armature, due to loose screws in armature head or worn bearings.

Procedure of Diagnosis.

If missing continues to occur and the cause cannot be located, then begin the diagnosis as follows; being sure that the

(1) Spark plug gaps are correct—about $\frac{1}{40}$ or .025 inch gap.

(2) Magnets are not weak.

(3) Interrupter points are clean and correct distance apart—about $\frac{1}{64}$ inch, see page 304.

(4) All connections are tight from magneto and switch.

(5) Magneto is properly set.

(6) Carburetor adjustment is correct.

(7) Armature is in perfect alignment—see page 302.

(8) Determine if missing occurs when running slow, or fast.

First Determine if the Trouble is Due to the Magneto.

By first running engine on the battery and coil system of ignition—then switch on to the magneto side—if the engine begins to miss, yet runs on battery side, this will indicate the trouble is in magneto.

Quite often, however, this test is made when engine is running slow and if engine misses only on slow speed, try setting plug points closer together and adjust interrupter or clean interrupter points, look for a loose wire or strand of wire short circuiting. If everything else, including carburetion is apparently o. k. **and engine runs on coil and battery, but misses on magneto,** then the trouble is likely due to weak magnets or punctured or short circuited insulation.

Before deciding it is the magneto winding giving the trouble, be sure magnets are strong—see test below, and **test magneto,** per pages 303, 302.

To Test Magneto on Engine.

First test which cylinders are missing, per figs. 1, 2, page 237. **If missing in all,** then trouble is likely in magneto or carburetion. **If in one regularly,** then likely due to spark plug or wiring.

Run engine slowly, advance and retard spark, note if missing, **then speed engine up** and advance and retard and notice if missing, thereby determining if missing is on low or high speed—then see page 298.

If engine is running and spark jumps $\frac{3}{8}$ of an inch and is blue and has volume and spreads when blowing on it, then it is not likely that magneto winding is defective. **If it will not jump this far regularly** and is thin and yellow and cause not elsewhere, **then test armature winding,** per page 304.

Note: Magneto could continue to give a weak spark, even though winding was defective, as only part of the winding may be cut out.

Magneto Repairs.

Attaching magneto to engine: A good plan for attaching is shown in fig. 1 (upper illustration), chart 147. The base, however, should be brass, or other non-magnetic metal, unless the magneto itself is provided with a brass or aluminum base.

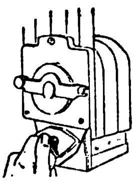
Magnetos are usually coupled to the shaft which drives it, in this case it is an easy matter to loosen the coupling and reset it. If, however, a coupling is not provided, then it will be necessary to remove the gear case cover and set by meshing the drive gear. A good type of coupling is shown in fig. 3 (upper illustration), chart 147. Another type is known as a **flexible magneto coupling,** this type permits the magneto being slightly out of line.

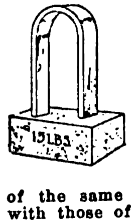
†Remagnetizing Magnets.

This subject is dealt with in chart 148.

To test if magnets need recharging. A good way to test, is to place a steel bar or pliers across the bottoms or the sides of the magnets on the magneto. If they pull fairly strong, you may know that they are in fairly good condition, and you can ascertain whether or not they are pulling fairly strong by testing some other magneto which you knew is all right. In doing this, however, turn armature so points are just separating.

Another method is to turn over the armature of the magneto by hand as shown below, and when the armature gets to a certain position resistance will be felt. This resistance is due to the breaking of the lines of force by the armature. Since weak magnets produce a weak field little resistance will be felt. The magnitude of the resistance will not be known to the repairman unless he has tried previously to turn the armature when the magnets were in good condition or unless he trys another magneto and compares the results.





Another test is to test the magnet's capacity of lifting 15 lbs. as shown. On small magnets 10 lbs. would suffice.

A good plan is to test the ability to lift of a new magnet of the same size, etc., and compare the results with those of the one just charged, or which you know is charged.

---

*See index for "testing coils with a test light," also pages 302, 304, 234; "testing coils."

†**A. L. Dyke, St. Louis is prepared to re-magnetize and repair coils and magnetos.**

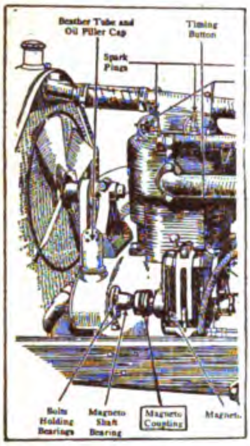


Fig. 4.—When a coupling is provided for the magneto to the driving shaft, it is a simple matter to set the magneto by uncoupling the coupling, otherwise the gears must be de-meshed.

The modern coupling is one with leather between—see page 312.

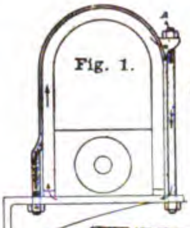


Fig. 1.

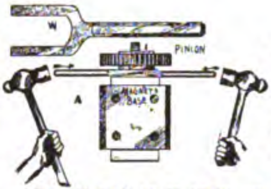


Fig. 2.—A special tool for removing gears Especially adapted for removing magneto gears on a tapered shaft.

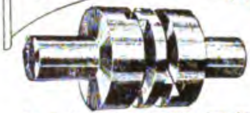


Fig. 3.—A good form of coupling from drive shaft to magneto. The Oldham used by Splitdorf

Fitting Magneto.

Fig. 1.—One method of fitting a magneto to engine frame is by means of pins, and is held down on its base by a strap of metal passing over the magneto—this is a favorite method. The band is usually in two sections, as illustrated in fig. 1 (above), thus bringing the nut (A), which tightens or loosens the band at a point which is easily gotten at. In other instances, however, the magneto is bolted direct to its base and since the nuts are below, it is almost impossible to remove the magneto after the engine has been placed in the chassis. It might also be worth mentioning, at this point, that some magnetos are strapped down on iron or steel brackets and no precaution taken to see that brass or non-magnetic fittings are used at the point (A) where the tightening bolts joined the straps. A little thought will show that, as illustrated, **a portion of the lines of force will return by way of the bolts and base instead of through the armature.** Although the effect of this may not be noticed at ordinary speeds, it will have much to do with determining the lowest speed at which a good spark is produced. **Magnetos therefore must have brass or aluminum base.**

Testing a High Tension Coil.

Connect the low-tension circuit of the coil with a new battery of the same size as is used on the car, and provide a spark gap of suitable size on the high-tension side.

For 60 lb. compression the gap should be ¼ in. in the atmosphere and for 90 lb., ½ in. **Fig. 2 (below), shows the conventional arrangement which may be used when the coil is not on the magneto armature.**

The low-tension circuit is closed and then quickly opened, and if the coil is in good condition a spark should occur at the high-tension gap, fig. 2, also see pages 234 and 236.

There is no necessity of removing the coil box from the car to do this work if the test wires are long enough to be attached with the coil in place.

Unless the internal wiring of the coil is known, some experimenting will be required in order to connect up with the right terminal. Probably the simplest method of procedure is to note the terminals to which the low and high-tension wires are attached, and attach the test wires accordingly.

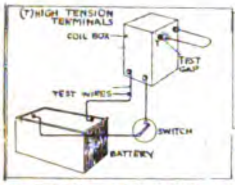


Fig. 2—A battery, switch and test wires are all that are necessary to test a coil

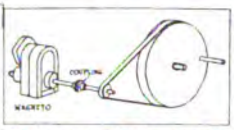


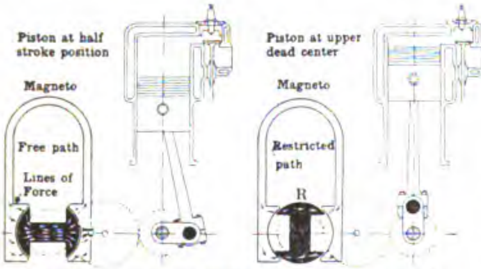
Fig. 5—Another method for determining the condition of the spark produced at high speeds

Testing a Magneto.

****Testing high tension magneto;** oil magneto; connect distributor wires to spark plugs **and set points** 5/16" **gap;** then run magneto 40 min. at 1,500 r. p. m. with interrupter full advanced and 10 min. at 3,500 r. p. m. full advance, and 10 min. 150 r. p. m. noting that it runs equally well during last run in either advanced or retarded position.

During the runs the contact points should not spark or flame excessively. There should be no excessive noise or stray sparks about magneto. The *safety gap in magneto should be 5/16" and should not spark at any of the above speeds if spark plug gaps are not over 3/16" during the test. The spark should jump the safety gap when armature revolves 60 r. p. m. with spark plug or distributor wires removed. **One method of driving a magneto on a test** is by an electric motor, per page 304. Another method is shown in fig. 5. When testing magneto or coil, run until heated up.

Be careful the armature is in perfect alignment. If a ball is broken the armature shaft will be out of line and permit armature to rub against pole piece, or armature heads may become loose, or drive shaft may be worn unduly on one end of armature by the gear driving it meshing too tight.



Left, position of magneto armature with piston of engine at mid-stroke showing free path for magnetic lines of force between poles of magnet. Right, position of magnetic armature with piston at upper dead center showing restricted path of lines of force through armature

How Poor Compression Weakens Magneto Magnets.

If engine has good compression piston will stop on quarter and not dead center. **Result, free path** for magnetic lines of force forming virtually a complete magnetic circuit per fig. 1.

If engine has poor compression, even in one cylinder, the piston will stop on dead center. **Result,** the path for the magnetic lines from one pole piece to the other is very poor and consequent result is the same as when a horse shoe magnet is allowed to lay around without its keeper—the magnets will gradually lose their magnetism. (from Motor World, by Thurston W. Turner.)

CHART NO. 147—Attaching Magneto to Engine. Couplings. Removing Magneto Drive Gears. Testing.

---

l tester consisting of meter and switch and instructions for testing coils can be secured of A. L. Dyke, Pub., is, Mo., price seven dollars. *See pages 273, 275, 299 for safety-gap principle. **See also pages 301, 304.

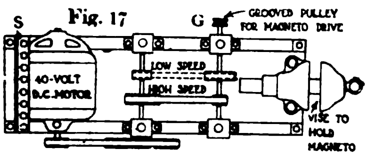


Fig. 17

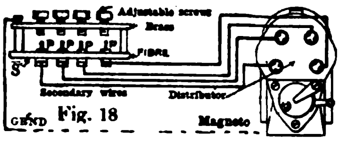


Fig. 18

Magneto Testing Apparatus.

When considerable testing is done, a countershaft with pulleys, and used in connection with a 1/6 h. p. electric motor can be used to run the magneto at various speeds to test the length of gap and volume of spark at various speeds—see fig. 17.

An adjustable gap arrangement can easily be made as per fig. 18 Note the length of the gap can be adjusted.

To test magneto, place it in the vise. Connect secondary terminals to the stationary points P. Place a grooved pulley on the taper shaft of magneto and connect it with grooved pulley G on the second counter shaft by means of a round belt. Then run magneto and test as per page 302 and 304. **If the spark does not test out satisfactorily then disassemble magneto and test armature** and condenser per page 304, 303.

To Test Condenser.

All high tension magnetos and high tension coils are provided with condensers, as explained on pages 273 and 228.

A condenser usually consists of 161 layers of mica insulation material, between which sheets of tin-foil are laid so that each layer of tin-foil is electrically insulated from its neighbor—see page 228. In some coil condensers the paraffined paper is used instead of mica which is not as efficient.

Condensers can be removed, but it is usually necessary to unsolder the primary armature winding connections to one of its terminals, the other condenser terminal being grounded to the armature frame, per fig. 1, page 268.

Usual troubles are due to the sheets of tin-foil becoming grounded, or one of the connections open. **Indication of a defective condenser** is excessive sparking at the contact-breaker points which become pitted white.

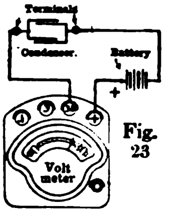


Fig. 23

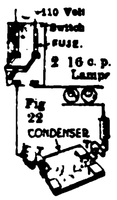


Fig 22

How to test: Use 110 volt direct current with one or two lamps connected as shown in fig. 22. **If condenser is properly insulated and not grounded,** the lamp will not light when switch is closed. **If it does light,** then condenser is grounded and if ground cannot be removed, a new condenser is necessary.

Another test is per fig. 23; use a 30 volt range volt meter and connect as shown (and page 414). **If condenser is good,** no indication will be obtained. **If it is grounded,** an indication will be obtained.

Magneto Magnets.

Magnets Made of Steel.

The magnets used on both low and high tension machines are of special tungsten steel made as hard as it is possible to obtain them, so hard that a sharp file cannot make any impression on the metal. Much depends on the class of steel used—a special grade known as magnet steel is now being adopted. **The retention of magnetism** by steel is a very curious and interesting property. **It resides only on the surface** of the steel, and it is found that a much stronger magnet is obtained, weight for weight, by making it in sections, one placed over the other, than in using a massive single magnet. **Magnetos** have two magnets placed side by side; some have a single large magnet—they were formerly two—superimposed.

Soft steel is easier to magnetize than hard steel, but the former loses it quickly if submitted to vibration. The hard steel magnet loses its magnetism very slowly, although the magneto has, as a matter of course, to withstand much vibration from the engine, etc.

Weak Magnets.

After magneto has been in use for **approximately** two years, the magnets may have become weakened. The length of time a magneto retains its magnetism is governed by the quality of steel used in the magnets and also, to reason explained bottom of page 802, see also page 301.

Misfiring will be the result of weak magnets. There are other conditions however, to determine before blaming the magnets, for instance the missing may occur from spark plug points not being set equal distances apart.

The best remedy for trouble from this source is obtained by having magnets of the magneto recharged; but temporary relief often may be obtained by adjusting the points of the spark plugs so that all are brought a little closer together; and all equally distant apart; that is, the gap between the points should be the same on all plugs. If the gaps are not all the same, then the plug with the widest gap generally will be the first to misfire, as a result of weak magnets.

When running a car slowly on the high-speed gear, the engine may be turning over so slowly that the magneto will not generate the required current and misfiring accompanied by a jerky action of the car will take place. When this occurs, one should either shift to a lower gear, or switch over onto the battery. The better plan is to shift to the lower gear, if in congested traffic when the car speed cannot be increased; for by so doing one speeds up the engine and magneto; more current is generated, a hotter spark and missing eliminated.

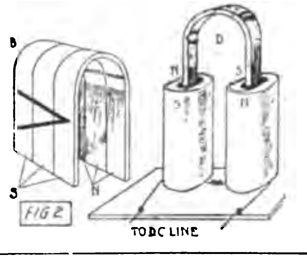
*Remagnetizing Magnets.

In charging by the use of an electro-magnet, one of which is shown at D (below), unlike poles must be placed together. That is, the north or N pole of the magnet should be in contact with the S or south pole of the electro-magnet and the south pole of the magnet with the north of the charging device. The electro-magnet has polarity because the fields are wound in opposite directions. It is determined easily whether the magnet is in its proper position even if the poles are not marked. Since like poles repel and unlike attract each other, when the magnet is placed in contact with the electro-magnet cores they should hold fast. If there is a repulsion then the magnet should be reversed.

After charging has been completed and the magnets are assembled onto the magneto it is necessary that like poles be in contact. That is, if the magneto has three magnets the north poles of these must be in contact as shown in fig. 2. Often some figure is painted upon the magnets, such as is shown, and when this figure is made by the assembly of the magnets the poles are properly facing. It is best then to determine the proper polarity by the attraction and repulsion methods; like poles repel each other and unlike poles attract each other.

Another method to find N & S pole: S pole of magnet will attract N pole of compass, see fig. 3.

Keeper: When magnets are disassembled, place an iron bar (called the "keeper") across ends to retain magnetism. This should be done instantly on removing magnets, or after remagnetizing.



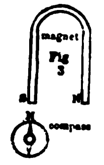


Fig. 3 — Finding polarity of a magnet with a compass.

CHART NO. 148—Condenser Tests. Magneto Magnets.

***A good magnet re-magnetizer** to operate from a 6 or 12 volt battery or dry cells, price $7.50, can be secured A. L. Dyke, Pub., St. Louis, Mo. An attachment to recharge Ford magnets, one dollar extra.

Testing The Magneto on The Bench.

It is not advisable to take the magneto apart unless you know it is defective. Before taking apart read pages 301 and 303 carefully.

To Disassemble the Magneto.

Remove interrupter, distributor block, gear housing, magneto and bearings. This will leave armature as shown in fig. 27. Be sure and place a "keeper" on the magnets the instant they are removed, per page 303.

To Test Complete Armature.

Use a 6 volt battery and test points as shown in fig. 27. Connect one test point with primary lead and the other test point (T), touch to armature core at (C) for instant. The current then travels through **primary winding and condenser, and is induced into secondary winding.

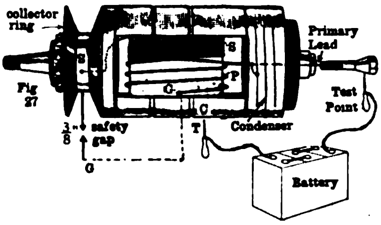


Fig 27

If **a spark** occurs at the test point, and at the same time it jumps the secondary gap of ⅜ inch, then we know the armature has tested out o. k.

If there is no spark at all, then we know that there is an open circuit in the **primary winding.**

If there is a heavy spark at the test point when touching core, then there is a short circuit in the condenser or primary winding and it is necessary to disassemble armature. This of course, would mean a dead short circuit on the battery.

To Disassemble Armature.

Remove screws, armature heads, collector spool, etc., as shown in fig. 22.

To Test Secondary Winding

***A single wound primary coil with a vibrator and condenser fitted internally can be used for this test.** A *Pfanstiehl coil, is excellent for this purpose, or a Heinze coil unit as used on a Model N Ford, with the secondary winding short circuited, could also be used.

Only the primary winding in connection with the vibrator is necessary, as the secondary winding on armature is used instead, hence reason for shorting the secondary terminals.

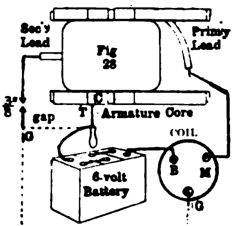


Fig 28

If secondary is o. k., then on touching **test** point (T) to **armature** core, fig. 28, the **spark** will jump the ⅜ **inch** gap.

If secondary is short circuited, the secondary spark on this test, will arc from secondary winding to armature core, but will not jump the **gap.**

If secondary is open, a spark could occur, as it could jump the open gap internally, but it would be weak.

To actually tell if a secondary winding is open, about the only plan is to put a very low reading sensitive voltmeter, connected with a 6 volt storage battery across the winding per fig. 29. If circuit is open, meter **needle** will not move at all. If it moves at all, then this circuit is o. k.

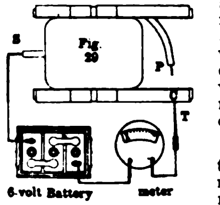


Fig. 29

Note: Never run **current** through armature **when** magnets are on the **magneto,** it may be **run through** in wrong direction and tend to demagnetize **them.**

Magneto Spark Plug Gap.

.020 to .025 inch or about **1/40** of an inch **is correct** gap. **If too wide,** starting will be hard **and** there is a liability of breaking down the high **tension** insulation of winding. **If too close,** they **are** more likely to become shorted, due to **carbon collecting** on gap points.

Compression of an engine determines type of magneto to be used. For instance if **magneto is** used on a high compression engine, then **points** must be closer than on a low compression **engine.** If, however, the magneto is made of **sufficient capacity** for the high compression engine, **then the** gap could be normal, or .025.

Contact Breaker.

Usual troubles are dirty points; platinum **worn** off; arcing at points; gap too **far** apart or **not far** enough; points not genuine platinum.

To test platinum points, use nitric acid, if it **eats** the points, they are not genuine platinum. **The** best test is to use a **jeweler's stone test** (**ask any** jeweler). Platinum, or platinum-iridium is **generally** used for points on magnetos and **Tungsten** (which is very hard), for points on battery **and** coil system interrupters. See also page 234.

Disassembly and Assembly of the Berling Magneto.

Fig. 22 shows how the parts of the armature on the type E and F Berling magneto disassembled. The interrupter which was first removed and the magnets, distributor, etc., are not shown. On most **magnetos** there **is but** one primary **connection** to the **condenser,** the **other** primary terminal **being** grounded, **also** one terminal of the condenser. **Here** primary leads **are** connected to condenser **and** one terminal of **condenser** is grounded which gives the same results. The primary leads are soldered to condenser.

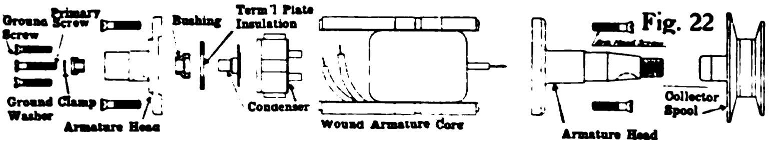


Fig. 22

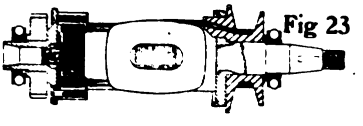


Fig 23

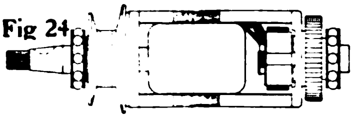


Fig 24

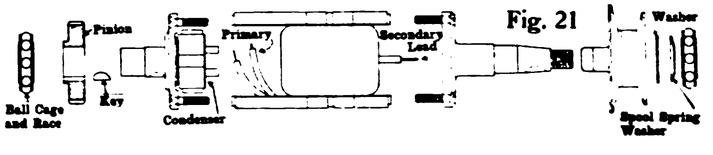


Fig. 21

Fig. 21 shows armature parts being assembled.

Figs. 23 and 24; **sectional** and top **view of** completed **armature.**

CHART NO. 149—Magneto Tests. Armature Disassembly.

*This coil can be supplied by A. L. Dyke (Elect. Dept.), Granite Bldg., St. Louis—price $7.50.

Secondary is grounded. On some magnetos it connects to **two collector rings.

INSTRUCTION No. 24.

*IGNITION TIMING: Advance and Retard of Spark. Relation of Time of Spark to Combustion. Relation of Spark to Speed. Relation Between Piston, Armature, Interrupter and Distributor. Setting the Time of Spark. Pointers in connection with Setting of Magneto. Setting Time of Spark of Vibrator Coil System. Setting Time of Spark on Engines of Leading Cars. Spark Control and Overheating. Finding Position of Piston. Conversion Table; degrees to inches.

Since in regular operation of the engine the charge is ignited just an instant before the top of the compression stroke, the **magneto** armature is so set relative to the engine crank shaft that the maximum induction effect occurs at this moment.

It is, however, necessary to be able to vary the point in the cycle at which the ignition occurs, since, when the engine is cranked by hand, the spark must occur after the end of the compression stroke, or else the engine may kick back.

If started by some form of self-starter it is then possible to start with slightly more advance than when starting by hand, because the self-starter turns the engine crank faster.

**Meaning of "Advance" and "Retard" of Spark.

The meaning of "**advance**" of spark; to cause the spark to occur **earlier**, before piston is on top of compression stroke.

The meaning of "**retard**" of spark; to cause spark to occur **later**. On engines that are cranked by hand, the spark is usually set "retarded" after top, so that there will be no danger of a kick back.

The exact position to "advance" or "retard" is determined by running as far "advanced" as possible at all times until a knock is detected, and then "retard" until the knock disappears. The driver will then soon learn the exact position where engine gives the greatest power. Remember also, that a retarded spark heats up the engine, see page 69 and 319.

Control of Spark.

Principle. As the spark occurs only when the primary circuit is broken by the opening of the platinum contacts, the timing of the spark can, therefore, be controlled, by having these platinum contacts open sooner or later. This latter is accomplished by the angular movement of the timing lever. This movement gives a timing range of about 35 degrees. The spark is fully retarded when the timing lever is pushed as far as possible in the direction of rotation of the armature and is advanced when pushed in the opposite direction.

Magneto spark control. In order to make it possible to vary the time of the spark on a magneto, the circuit breaker housing (F, by means of lever L, chart 130, also fig. 3, chart 150) is so arranged that it can be rocked around its axis, being provided with a lever arm for the purpose, from which connection can be made to a spark lever on the steering post.

It will readily be understood that if the armature shaft turns right-handedly, and if then the circuit breaker housing is moved through a certain angle in a right hand direction, the contact points A and B will separate later, with relation to the position of the engine crank shaft; while on the other hand, if the housing F is moved in a left hand direction the circuit breaker point will open earlier. In this way the point at which the spark occurs can be shifted through an angle of about 35 degrees.

Coil and battery system control: On the Delco and Atwater-Kent or similar systems; the advance and retard is obtained by shifting the housing surrounding the timer and distributor and also by governor action (see charts 117 and 143.)

Spark Control Methods.

There are three general principles used for control of spark: (1) by hand, to vary the spark position, which would be termed "variable spark;" (2) by a governor, which would also vary the spark according to the speed; (3) a fixed spark.

(1) By hand means the spark lever on the steering post shifts the commutator or interrupter. (see pages 222, 248, 66.)

---

*For ignition systems, firing orders, valve timing, etc. of motorcycle engines—see Dyke's Motor Manual.

**Also see pages 61 and 68.

Fig. 1

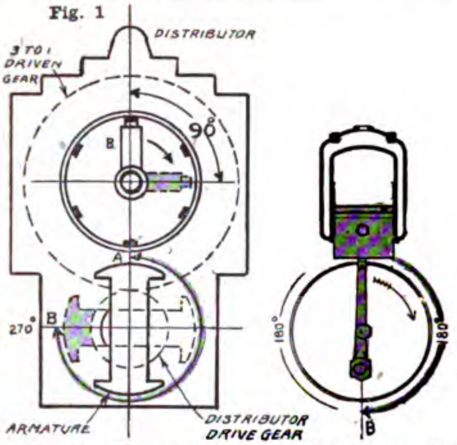


Fig. 2

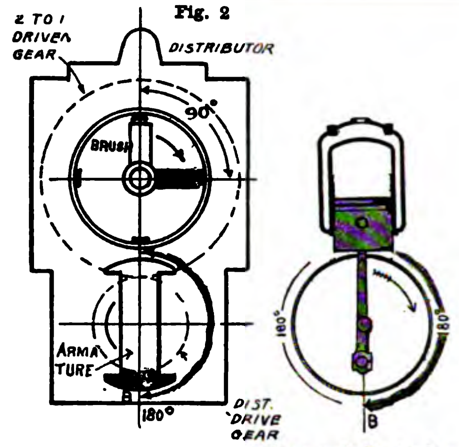


Fig. 1.—Six cylinder magneto speed relation: Note when piston makes a full stroke, or crank travels 180° or one-half of a revolution. Armature would turn ¾ of a revolution or 270° (A to B).

Therefore if crank pin made one complete revolution, the armature would make twice ¾ or 1½ revolutions. During this 1½ revolutions it would have made three impulses.

When the engine crank makes another revolution, then the magneto armature would make 1½ revolutions more or three revolutions to two of the crank, therefore, it would make six sparks during the three revolutions of armature or two revolutions of the crank shaft. Therefore the armature would then be geared to run 1½ times as fast as the crank shaft.

The six cylinder engine crank must make two revolutions to complete its four cycle operation, therefore it would require six sparks during the two revolutions (720°).

The distributor, however, having the six plug connections to make during one revolution of its rotating brush (B), would have to be geared so it would make a connection every 60°.

For instance, if crank traveled 180°, the distributor would travel 90°.

If crank traveled one revolution or 360°, distributor would travel 180°.

If crank traveled 720° or two revolutions, distributor would travel 360° or one revolution.

If one of the cylinders fired every 120° (or one-third of a revolution), there being six cylinders to fire during two revolutions or 720° travel of crank, then we would need six sparks or impulses during 720° travel of crank.

Distributor being geared one-half the speed of the crank shaft, the segments would be placed 60° apart, therefore, when crank traveled 120° and required a spark, distributor brush (B) would travel 60°. There being six segments 60° apart, this would give six sparks or impulses during two revolutions of the crank.

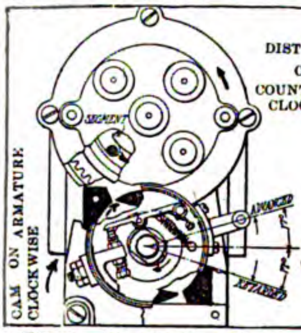


Fig. 3.—Illustration showing circuit breaker in "advanced" position when magneto armature is running "clockwise"—(right hand). Note cam turns to the right and distributor to the left.

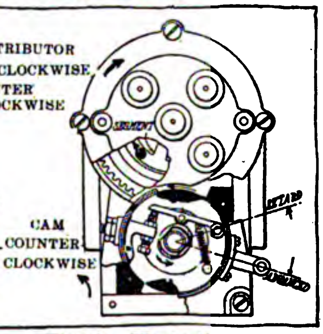


Fig. 4.—Illustration showing circuit breaker in "advanced" position when magneto armature is running "anti-clockwise"—(left hand). Note cam turns to the left and distributor to the right.

Note—Although the illustrations, figs. 3 and 4 show the cam and distributor, viewed from the interrupter side of magneto, as running clockwise and anti-clockwise, the rule is to view magnetos from shaft end—and thus speak of it as clockwise or anti- or counter-clockwise—see pages 313 and 296.

Fig. 2.—Four cylinder magneto speed relations: Note if crank of engine travels 180°, armature also travels 180°. Both traveling at the same speed. The four cylinder engine requires four sparks during two revolutions of the crank.

The armature gives two sparks or impulses every revolution, therefore traveling at the same speed as the engine crank it will give four sparks during two revolutions.

The distributor would be geared one-half the speed. Every time the crank shaft moved 180° or half revolution it would move 90° or ¼ revolution.

The distributor always runs one-half the speed of the crank shaft on all four cycle engines.

CHART NO. 150—Explanation of Speed Relation between Crank Shaft of Engine, Magneto Armature and Distributor. Six and Four Cylinder Type of Magneto as an Example.

If a magneto is used, the housing which the interrupter arm is placed on, is shifted in opposite direction of rotation to armature to "advance," or cause the spark to occur earlier, or, in the direction of rotation to cause the spark to occur later—chart 150.

When the spark is advanced or retarded by hand, it is left to the good judgment of the driver to manipulate the spark lever; except where the system is equipped with an "automatic" advance.

(2) ***The automatic advance** is probably the most satisfactory with battery and coil system of ignition, because the spark occurs just at the right time automatically, and there is no guessing as to just how far to advance or retard at various speeds, see pages 249 and 246.

(3) **The fixed spark is sometimes used with a high tension magneto, which means, the time of spark is fixed at one position,** usually advanced, and the contact breaker, breaks at one position regardless of speed. This system has not proven very satisfactory on engines where speed varies, but would be satisfactory if the speed of engine was constant and did not vary. The objection, however, would be in starting—liability of a kick—for the spark would necessarily be placed advanced for proper running. (see page 311.)

The disadvantage in one instance; suppose the car was running up hill, the charge of gas would be heavy and throttle would be open, consequently a high compression. If the spark was advanced, which it usually is with a fixed spark, the spark would occur at such a time that the combustion would take place before piston reached the top, because piston would be moving slow at ten miles an hour; the result would be, the force would be exerted on the head of piston causing the momentum of piston to buck against the force of the combustion, which would invariably cause a knock and loss of power.

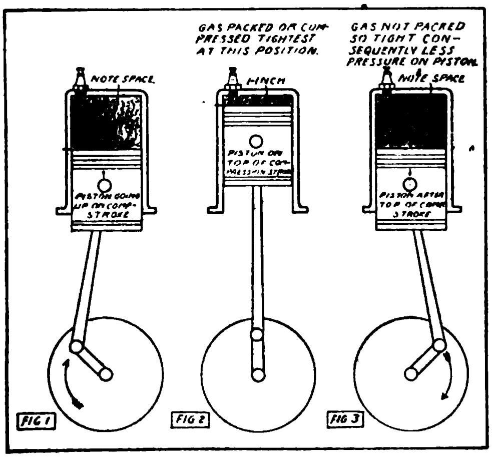
A remedy, but one that is not efficient, would be to cause the combustion to take place later, say on top or after top of compression. We could not do this by shifting the time of spark, therefore, about the only resource would be to enrich the mixture, by partly closing the air intake on carburetor. This would cause more gasoline to be taken in and the "rich" mixture would be slower to combust, and the effect would be the same as retarding the spark.

Where cars are equipped with a "fixed" spark, a rod could be fitted to the air valve lever to the dash. The fixed spark, however, is not at all advisable on variable speed engines.

Relation Between the Time of Spark and Time of Combustion.

The combustion should take place as the piston is on top of the compression stroke, (fig. 2), because at that point the gas drawn into the cylinder has been forced up into the head of the cylinder and is at the point of greatest compression—hence more force exerted on the head of the piston when the explosion occurs.

If it occurs **after** the piston has started down, the compression it not as great. If **it occurs before** the piston reaches the top of the compression stroke, it is not as great. If running slow, the explosion occurring before the top of the stroke, the force will be exerted against the pistons travel, and will cause knock and loss of power.


GAS PACKED OR COMPRESSED TIGHTEST AT THIS POSITION.
GAS NOT PACKED SO TIGHT CONSEQUENTLY LESS PRESSURE ON PISTON
NOTE SPACE.
1-INCH
NOTE SPACE
PISTON GOING UP ON COMP-STROKE
PISTON ON TOP OF COMPRESSION STROKE
PISTON AFTER TOP OF COMP STROKE
FIG 1
FIG 2
FIG 3

An example: Fig. 1—Note the piston is going up on compression stroke, pushing or compressing the gas (which was drawn in at the previous suction stroke), into the head of cylinder. At the point piston is now, the gas is not very tightly compressed.

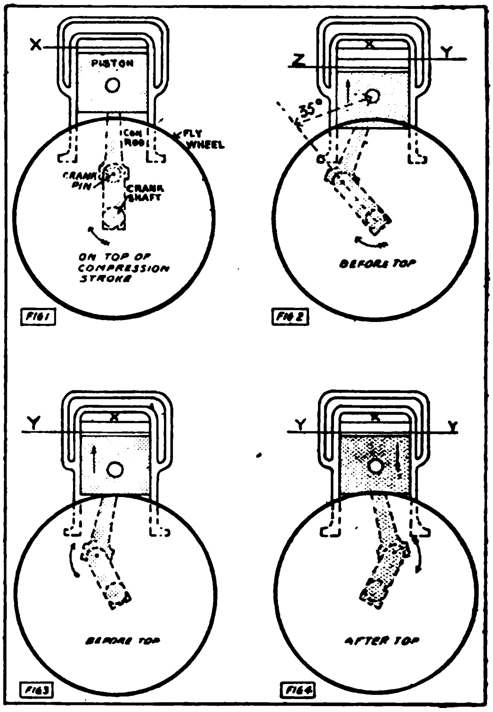
Fig. 2—The piston has now reached the top of compression stroke and the gas is packed tight into the head of cylinder. It is clear that if the combustion took place at this time—the force against the piston would be greater than if the combustion did not take place until piston had passed over the top and was on the way down, as in fig. 3.

Also observe that if the combustion took place before the piston reached the top of the compression stroke, as in fig. 1, especially if running slow, the power would be exerted on the up coming piston's momentum and not only cause a falling off of power, but a knock would occur, caused by the sudden reverse force.

Remember, the momentum of the fly wheel carries the piston up and down on the other three of the four strokes.

---

*Note—This automatic spark control takes into account variations in speed only. See pages 246 and 249.



Time for the Spark to Occur.

There is a difference in time, between the time the "spark" is made at the spark plug, and the time the "combustion" of the gas actually takes place. If combustion took place immediately that the contact was made or broken, then the proper time to set the spark to occur would be on top of the compression stroke.

But as stated, there is a slight difference in time allowed for the gas to burst into full explosion after spark occurs; but as we desire that full explosion occur at the highest point of compression, **we will figure out just how we can make the combustion take place at the highest point of compression.**

***First: We must figure out how far in advance of the top of the compression stroke the spark must be set to occur,** in order to have combustion take place on top of the compression stroke.

There are two main points to be considered; the system of ignition being one; if a coil and vibrator system is used, then it is natural to suppose that the time consumed in making contact on the commutator and the time of action of the vibrator, will consume more time than a single contact, as in a magneto or single spark system. Therefore if a vibrator coil system is used, we would have to set the spark to occur a longer time before the top of the compression stroke, than if a quicker single spark system of ignition was used.

The second consideration is speed; if the piston was traveling slow, the spark would be set (retarded) to occur later or nearer the top of compression stroke—than if engine was running fast.

†Speed Relation to Time of Spark.

Suppose engine was running 500 revolutions per minute. Taking (X), fig. 3, as top of compression stroke; the distance to set spark would be, say at (Y), in order to give the combustion time to take place when piston was on top of compression stroke.

Now if the spark was fixed to occur at (Y) (fig. 3), and speed was increased to 1000 revolutions per minute, then the piston would go to the top of compression stroke at (X), (fig. 4), and pass over it and down to (Y), on the other side or down in power stroke, before the process of combustion was completed. The result would be a loss of power during the pistons down travel between the points (X) and (Y) (fig. 4), the full force of the explosion not being exerted on the piston until the latter point (Y) was reached.

To increase this, it will be necessary to recalculate the piston speed at 1,000 r. p. m. and set the spark at a point say, (Z), fig. 2, which will allow of complete combustion by the time the piston reaches the top of compression stroke (X).

Setting the time of spark to occur before the top of compression stroke, is called advancing the spark.

In setting a magneto—the usual extreme range of advance on a magneto is 22 to 35°, therefore if you wanted to set the spark to occur 35° at full advance position so that you could have spark occur 35° before top, when running at full speed—simply place piston on top of compression stroke, set contact-breaker in "retard" position.

If you only wanted 30° advance at full speed, place piston 5° past the top of compression stroke and set breaker box housing at full retard.

**Speed Relation between Crank Shaft of Engine and Cam Shaft. Also Armature of Magneto and Distributor.

On a four cylinder, four-cycle engine, crank-shaft turns two revolutions (or 720 degrees) to complete its four-cycle operation, explained on page 58: cam-shaft turns 1 revolution; magneto armature turns 2 revolutions; magneto distributor brush, 1 revolution (see pages 294, 306).

Four sparks are necessary during the 2 revolutions of crank-shaft, therefore, as magneto armature turns 2 revolutions, same as crank-shaft, it produces 4 sparks, or a spark at every ½ revolution. **Distributor brush** is geared to turn ½ the speed of magneto armature, therefore, it will turn 1 revolution (360 degrees) to 2 revolutions of crank- shaft. As the 4 contact segments on distributor are spaced 90 degrees apart, then 1 revolution of distributor brush will make 4 contacts, producing 4 sparks 90 degrees apart during 1 revolution of distributor brush, or 180 degrees apart relative to crank-shaft, or 4 sparks to 2 revolutions of crank-shaft (see page 294 and fig. 2, page 306).

A two-point cam is used on magneto contact-breaker, which interrupts the primary circuit twice during each half revolution of armature.

On a six-cylinder, four-cycle engine, crank turns 2 revolutions to complete the four-cycle operation, just the same as the four-cylinder engine. The cam-shaft also turns the same as the four-cylinder engine, that is, 1 revolution to 2 of crank-shaft.

---

*See page 311. †See also page 319. **See also pages 294 and 306.

But six sparks are necessary during the two revolutions of the crank-shaft, because the crank shaft is divided into three pairs of throws (see page 122), each pair firing 120 degrees apart, or ⅓ of a circle. It is then necessary to gear magneto armature so it will turn 3 times to the crank-shaft 2, or 1½ times to each revolution of crank-shaft. Armature produces 3 sparks during 1½ rev., or 6 sparks during 3 revolutions (see page 306, fig. 1). **Distributor brush** must turn 1 revolution to crank-shaft 2, therefore, if armature turns 3 times when crank-shaft turns 2 times, then distributor is geared from armature shaft to turn 1 rev. when armature turns 3 rev., or ⅓ rev. when armature turns 1½ rev.

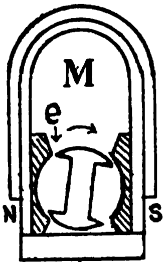
As the 6 contact segments on distributor are set 60 degrees apart, then 1 revolution of distributor brush will make 6 contacts, producing 6 sparks 60 degrees apart during 1 rev. of distributor brush, or 120 degrees apart relative to crank-shaft, or 6 sparks to 2 rev. of crank-shaft (see pages 306 and 294).

A single cylinder, four cycle engine requires only one spark every other revolution. The usual practice, therefore is to pass over one of the two "maximum" positions of the armature, simply by omitting one of the two cams, thus leaving primary winding short-circuited. Therefore as magneto is driven at cam shaft speed in this instance, a single spark is obtained.

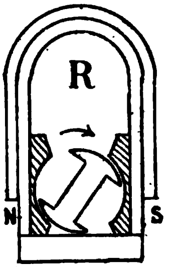
Relation Between Position of Armature To Contact-Breaker When Advanced or Retarded.

Advanced position: Referring to (M), the armature cheek is just breaking from pole tip (e), in direction of rotation. This is the **maximum** position, or when current strength is strongest. At this time the contact-points (P), fig. 4, should separate. We learned this on pages 266, 267.

The magneto is set at the factory with armature in maximum position (M) and the contact-breaker housing fig. 4, is placed in an advanced position. That is, it is moved opposite to direction of rotation of cam (c). The cam (c) is set so that it causes points (P) to separate when contact-breaker housing is in the advanced position.



Armature in maximum position



Armature in retarded position

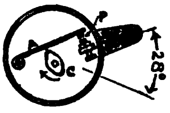


Fig. 4—Contact-breaker advanced

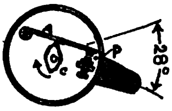


Fig. 6—Contact-breaker retarded

Retarded position: Suppose the contact-breaker housing is **retarded**, or moved with direction of cam rotation as far as it will go, fig. 6, (†28 degrees is average range), then points (P) of contact-breaker would not separate until armature had traveled *further in the direction of rotation, approximately the position shown in (R), at which point the armature has passed the maximum position and where the current strength is weaker. By referring to pages 266 and 267, we learned that the current strength begins to weaken the nearer armature travels to zero position after maximum position.

From the above explanation we learn that the spark is strongest at maximum position of armature (M), with contact-breaker in advanced position (fig. 4)—and that spark is weaker when contact-breaker is in retarded position (fig. 6)—because armature has passed the maximum position.

Let us see what happens when we follow out the magneto-setting given on page 310, which says: place piston on top of compression stroke, place contact-breaker in retarded positon, then turn armature in direction of rotation until contact-points just start to separate.

This would place the armature in position (R), and contact-breaker in position, fig. 6—both retarded. In this position the spark would occur when piston was on top of the stroke—but we must remember that the combustion is not instantaneous, therefore allowing for this lag, then the spark would occur when piston had moved slightly down **after top**—which at slow speed is desirable, but a weaker position of armature for starting engine on.

This is why spark plug points ought to set close together and why magnetos do not permit engine to throttle down as slow as a constant source of electric supply, such as a battery. The contact-breaker is usually retarded when engine is running slow and magneto armature is turning over slow, for reason stated on page 308, therefore both actions tend to weaken the spark. Always run as far advanced on magneto ignition as possible.

****As the speed of engine increases;** if contact-breaker was retarded and combustion was not instantaneous, as explained above, then the piston traveling fast, would move further down after top before spark occurred—therefore as we have a range of 28° which we can move contact-breaker housing so that spark will occur earlier, we then **advance** the contact-breaker more and more as the speed of engine increases, so that spark will occur **before** top of compression, thereby giving the combustion time to take place, when piston was on top or just starting down. The more we advance the breaker, the nearer we reach maximum or strongest position of armature. Therefore the current strength is greatest at high speeds.

When setting a magneto, the only point to consider is if breaker housing is to be retarded or advanced when interruption takes place and position of piston.

---

†The average advance range of armature is 22° to 35°—many magnetos actually having but 22° or 28° in which breaker moves from full advance to full retard. The Bosch Co., state that the Bosch 4 cyl. standard average speed (less than 2000 r. p. m.), has a timing range of 35° figured on magneto axis. **On a timer or commutator,** it is possible to get as high as 48°. For instance the Atwater-Kent timer; the timer shaft will advance automatically about 15° at high speed and the housing itself can be advanced about 33°—see page 248. **See also pages 308, 319.

***About 1/16 in. break from cheek of armature to pole-piece** (e) when advanced, is the average break. The distance at full retard, would be about 23/32 in.

A 4 cylinder engine with a speed of 2000 or less, is termed average speed and gap between pole piece and armature cheek is 1/16 in. **An engine with speed of 2000 to 3500 r. p. m. would be termed a high speed engine** and in this case the gap opening is increased to 5/32 or 3/16 in.

Setting the High Tension Magneto—"Retarded On Top."

(1)—Place No. 1 piston on top of compression stroke. To find compression stroke, see page 320.

(2)—Uncouple magneto from its drive shaft (see page 302, fig. 4). If magneto cannot be uncoupled, then time from magneto gear and gear driving it, by taking them out of mesh.

(3)—Retard the breaker box (also called interrupter) (F), by turning it in the direction of rotation of armature shaft, as far as it will go.

(4)—Turn armature in direction of rotation until the distributor arm (DA) is on segment (S) of No. 1 spark plug cable connection, then turn armature, one way or the other slightly; until interrupter arm (A), is just starting to separate the platinum point connection (P) with (K), which of course is caused by cam action as shown. In other words, just as the points start to separate, is the time to set the magneto.

(5)—Couple magneto shaft, or mesh gears driving magneto at this point, being careful to not move either the armature or piston—(see page 312).

(6)—Now see that wire cables from distributor are properly connected, as explained on page 296. In this instance, by looking at the distributor connections and noting direction DA turns, the firing order would be 1, 3, 4, 2.

The above setting is for retarded position of interrupter and piston on top—this setting would allow the spark to occur considerably **before** piston reached top of stroke when **interrupter was advanced, which** is usually the case with high speed engines, and the average and **usual setting.** Exact settings cannot be given—see page 311.

Setting Magneto "Retarded—After Top."

If instructions said, place piston say, ⅛ inch down after center of compression stroke with breaker box retarded, then this would not permit advancing spark so far ahead of stroke, and in some instances, this is done on slow speed engines and where very slow running or idling is desired, as truck and tractor engines.

NOTE—The armature turns in opposite direction to distributor, therefore always note direction distributor turns before connecting cables to plugs. To tell how an engine fires if you do not know—see page 120.

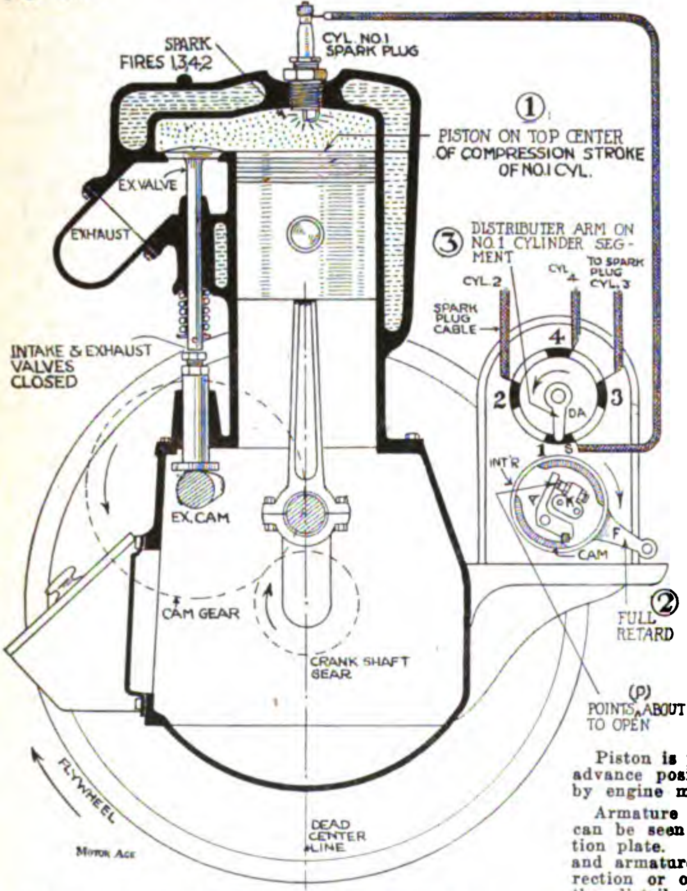
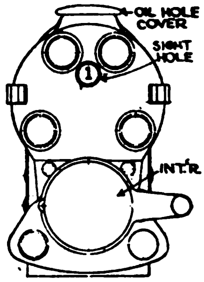


Fig. 1.—Diagram showing how a high tension magneto is usually timed; interrupter housing (F) is retarded and piston is placed on top center of compression stroke.

The breaker box (F) is stationary. The arm (A) and (K) revolve with armature.

Usually when viewing magneto from front of engine, the magneto would be facing in opposite direction—towards fly wheel, as the rear end of a magneto is usually driven from front of engine (see fig. 4, page 302 and page 312.)

When breaker points are just breaking, the armature cheek, breaking from pole (fig. 2, page 313) is in correct position, as it was set at factory. Likewise the speed of distributor to armature. See top of page 301.



Magneto Setting by Sight Hole.

Fig. 2. In some magnetos, ZR Bosch for instance, the magneto can be set by observing sight hole.

Piston is placed to firing position, for full advance position. This point is determined by engine manufacturer.

Armature is then rotated until fig. "1" can be seen in window in face of distribution plate. Cover of oil well is then raised, and armature turned few degrees in one direction or other until red mark on one of the distributor gear teeth is brought into register with red marks on the side of the window. Magneto is then turned for full advance position, and gear or coupling is secured to armature shaft. See top of page 297.

CHART NO. 150A—Setting the Time of Spark of a High Tension Magneto.

also pages 290 and 292.

Seting Time of Spark of Magneto.

There are three general positions of piston, for setting the time for the spark to occur with the magneto:

(a) **Top** of compression stroke.
(b) **After** top of compression stroke.
(c) **Before** top of compression stroke.

A variable spark is where the breaker can be shifted to **advance** or **retard** the time of spark.

A fixed spark is where the breaker (or interrupter) is set or fixed at one position and cannot be varied. (see page 307.)

In setting a magneto of the fixed spark type, the instructions in reference to the moving of the breaker housing to the extreme advance or retard position are to be disregarded. The magneto should be set so that the spark occurs at the most advantageous point in the cylinder. This should be decided upon by the engine manufacturer, but where such information is not available, the spark should occur **at top-center.**

In setting a magneto of the variable spark type, one of three methods can be used:

(a)—by setting the piston on top of compression stroke and setting magneto breaker retarded. In this instance the most advantageous position of the piston for the spark to then occur, when breaker is fully advanced, is determined by how much advance the magneto is capable of giving. A high speed engine requires more advance than a slow speed engine. Magnetos vary from 22° to 35° or more. However, this is the average and general setting as explained on page 310. This is termed **"setting piston on top and ignition retarded."**

(b)—Sometimes, on truck and tractor engines and others, the spark is made to occur, when piston is down after compression stroke slightly—and breaker retarded. This would not permit advancing spark so far ahead of stroke—unless a magneto with a greater range was used, but this is done on slow speed engines and where very slow running or idling is desired.

(c)—By setting the piston before top of compression stroke and advancing the breaker would be termed **"setting ignition advanced."** The point to determine here, as to where to set the piston depends entirely upon where you wish spark to occur when breaker is fully retarded. For instance, suppose magneto range of advance was 35° and you wished spark to occur on top of compression stroke, simply set piston 35° before top, with magneto breaker full advanced. This would mean the same thing as setting piston on top with magneto retarded.

How The Instructions For Setting a Magneto Vary.

(1)—**set by marks on fly wheel.** Usually designated on fly wheel by a mark "C" or "F". This mark is placed in line with a punch mark on cylinder which indicates that piston No. 1 is on compression stroke and the magneto is to be set advanced or retarded as instructions may be given, at this point.

(2)—**by inches;** should the time for spark to occur be given in inches, for **example;** "time for spark to occur is full advanced position measured 3½ inches on fly wheel, before upper dead center."

These are the instructions given to set the valves on the Simplex engine, which is 4⅝ in. bore, 6¼ in. stroke and 18¾ in. fly wheel.

We would simply set spark lever or breaker on magneto 'at "full advance" position. Then turn fly wheel until the top center of compression stroke was reached—at this point a center mark on fly wheel is in line with a center mark on inspection hole. To have spark occur 3½ inches, as measured on fly wheel, would mean to turn fly wheel back or before top of compression stroke until this center line was 3½ inches away from center line on inspection hole. This would be the position for spark to occur.

The armature of magneto would then be uncoupled, breaker advanced, and armature turned slightly until points were just starting to separate. The coupling would then be tightened This setting would cause spark to occur 21 degrees before top of compression stroke, with breaker housing **advanced.** (I found the degrees by referring to table on page 115).

(3)—**by measurement of armature from pole piece,** as per fig. 2, page 313, note (e), which is the distance the armature is to be set with piston on top and breaker points separating (see top of page 301).

(4)—**by sight hole,** per fig. 2, page 310.

(5)—**by degrees;** should the firing position be given in degrees, the movement of the piston, measured in inches corresponding with any given number of degrees of the crank shaft (where the relation of the crank shaft throw to the length of the connecting rod is as *1:5.4) may be determined by reference to diagram, page 314.

Example: suppose you were instructed to set the spark 34° before top of compression stroke—"advanced," on an engine with 5½ inch stroke.

(a) Turn to table on page 314; find 5½ inches at bottom. Next find 34° to right. Follow instructions for finding result given in chart. The distance in inches to place piston would be midway between ¼ and ⅜ of an inch from top.

(b) With this information you would then proceed to place piston, say, within 5/16 inch of top of compression stroke.

(c) The interrupter housing would then be full advanced and armature turned in direction of rotation until the cam just started to separate the interrupter points.

Timing the Bosch Dual Magneto.

This system is explained on pages 280 to 282. Note that there is a **battery interrupter** and a **magneto interrupter** (see fig. 6A, page 281). Although both are in the same housing on front of magneto—but one setting; that of **setting the magneto** **interrupter is necessary.

The battery interrupter is so arranged that it will then interrupt or break its circuit approximately 10 **degrees later** than the magneto interrupter; this feature gives the full timing range of the magneto. For instance; if timing lever is fully retarded and **magneto interrupter** set to break when piston is on **top** of compression stroke, the **battery interrupter,** with switch in battery position, would break slightly **after** top or 10 degrees later. Therefore set the **magneto interrupter** just the same as you would set the Bosch independent **type** of magneto.

Setting Bosch Independent Type.

Place piston on **top** of compression stroke and interrupter **retarded** as explained on page 310.

Magneto Drive Shaft.

Is usually tapered, therefore the coupling should be tapered to correspond. If driven by a gear, and teeth are meshed too tight, undue strain will result on bearings.

Breaker and Spark Plug Points.

Magneto points on dual system should be adjusted to open about 0.35 millimeters or slightly under 1/64 inch, and **interrupter points** full 1/64 inch. **Spark plug points** should have a gap of about 1/64 inch to .025.

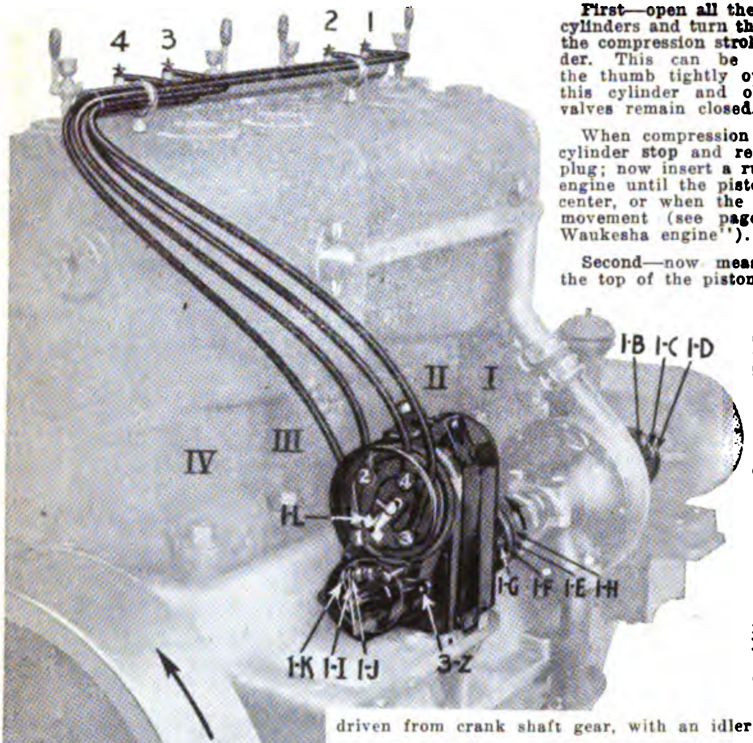
---

*1:4.5 is a ratio equation and means (as 1 is to 4 5/10) or in other words, the connecting rod is 4½ times longer than the crank throw. **See foot note page 298.

Example of Setting Time of Spark by Position of Piston.

Engine used in this example is the Waukesha 4 cylinder truck and tractor engine, **per** pages 833 to 838, using a high tension magneto for ignition.

In case the magneto has been removed from the engine and its connections have not been previously marked it can be retimed as follows:



First—open **all** the **priming cups on top of** cylinders and turn **the engine over slowly until** the compression stroke **begins in No. 1 cylinder.** This can be ascertained by **holding** the thumb tightly over the priming **cup of** this cylinder and observing that both **the** valves remain closed.

When compression stroke begins on **No. 1** cylinder **stop** and remove the cylinder **head** plug; now insert a ruler and slowly turn **the** engine until the piston comes to upper **dead** center, or when the ruler ceases its **upward** movement (see page 836, "timing **valves,** Waukesha engine").

Second—now measure the distance **from** the top of the piston to the top of **cylinder.**

For example, let us say that the distance measures 2 inches from the top of the piston to the top of the cylinder. Turn the crank over until it measures 2⅛ inches. This means that the piston has made a drop of ⅛ of an inch after top, on firing or power stroke, at which point the spark should occur. Replace the cylinder head plug to prevent any obstacles from falling in the cylinder.

Third — remove the bolts (I-B) which connect the flanges (I-D and I-C) (or leather coupling I-G to I-H could be disconnected). Magneto is driven by a gear in front of engine, which is driven from crank shaft gear, with an idler gear between.

Fourth—set breaker (or **interrupter**) **cam** in such a position **that** the distributor arm (I-L) will come on the No. 1 cylinder high **tension** terminal in the distributor and so that the contact screws (I-K, I-J) of interrupter, are just starting to open. **Letter** (I-I) **represents** the opening between the platinum contacts (I-K, I-J) with the **spark lever in the fully retarded position.**

Fifth—replace the bolts (I-B) in the flanges (I-D, I-C); that is, one on either side of the coupling.

Sixth—attach the wire which leads from the spark plug on No. 1 cylinder to the terminal marked No. 1 in the distributor p.ate; No. 2 spark plug wire to the terminal marked No. 2; No. 3 spark plug to the terminal marked No. 4, and No. 4 spark plug wire to the terminal marked No. 3. (see page 296.)

Never allow the ignition wires to lie on or near the exhaust pipe, as the insulation will burn off **and** lay the wire bare, causing a short circuit. **Spark plug gaps are** $\frac{1}{32}$" apart. **Interrupter points** .020.

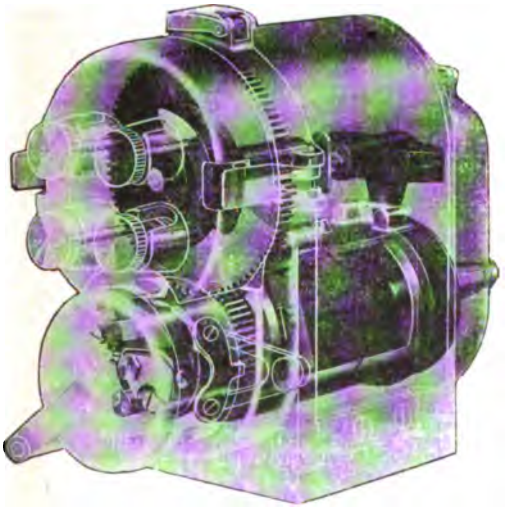
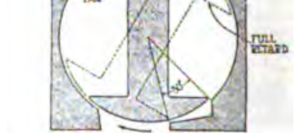


Fig. 2—A phantom view of the E-41 Berling high tension magneto. A "gap-distributor" is used (see pages 245 247, 261). Usual setting, is as per page 310; retarded. piston on top. Interrupter adjustment is .020. (Ericsson Mfg. Co., Buffalo, N. Y.)



Special pole piece used on Simms magneto to give equal spark intensity at all speeds

A special feature of the Simms magneto is the design of the pole pieces which have extensions **on** tne edges following the direction of rotation **of** the armature. These extended edges **keep the edges** of the armature shuttle within influence of the **pole** in all positions from full advance to full **retard.** That is to say, that at the moment of **breaking the** current the edge of the shuttle **is never widely** separated from the edge of the pole piece. **Therefore** current is generated at low or high **speeds** without much loss of intensity.

CHART NO. 130B—Example of Setting Magneto and Illustration Showing How The Magneto is Usually Driven. Note magneto faces rear of engine. **Berling High Tension Magneto. Simms Magneto.**

Timing the Remy Magneto, "RL" Model. (See page 264.)

Model RL is to be timed to the engine by the break of the contact points. When the piston is on exact dead firing center, cam house must be in full retard position, and the platinum points must just be separating.

The high tension cable from this cylinder, which is in exact dead firing center, should then be connected to the distributor terminal, corresponding to which the distributor segment is opposite.

The remaining distributor terminals should then be connected up in the proper firing order of the engine.

The position of the "inductor or rotor" type armature, is just the same as on a "shuttle" type armature; the interrupter should just be breaking when the "rotor" is just leaving the vertical position.

Sectional cuts explaining the Remy magneto with its inductor type of armature, are shown in chart 126. Set breaker points .025 inch gap.

**Timing the Eisemann Magneto.

To set this type, turn engine by hand until piston of No. 1 cylinder is on the dead center (compression stroke). Place the timing lever of the magneto to fully retarded position, then turn armature of magneto until No. 1 appears at the glass dial of the distributor plate and make sure that the platinum contacts of the magneto are just opening. Fix the driving medium in this position.

In order to insure absolute safety when cranking on battery, the contact breaker of the battery system is arranged so that it will open 10 degrees later than the magneto contact breaker.

Timing the Splitdorf Magneto.

Set piston on top of compression stroke with interrupter retarded.

Now revolve the armature shaft in its direction of rotation until the oval breaker cam comes in contact with the breaker bar and just begins to separate the platinum contacts. Set coupling or gear at this point.

Pointers in Connection with the Timing of a Magneto.

In timing a high tension magneto to an engine, we will assume a 4-cylinder, there are several points to be considered.

Firstly—Which way is the armature of the magneto to revolve? This will be settled by the construction of the engine.

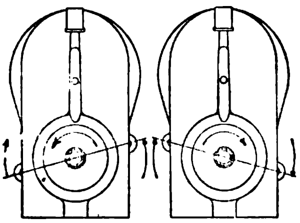


Fig. 5—Positions of full retard of the cam plate when looking at the driving end of the Simpler magneto. The first view is the counter-clockwise setting and the other the clockwise setting

The magneto will probably have to be driven off one of the timing wheels, and it will depend upon the direction of rotation of these as to which way the magneto must run.

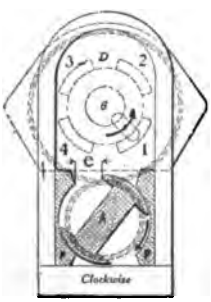


Fig. 2. Setting the Bosch Dual Magneto, when running "clockwise."

***Clockwise and anti-clockwise:** Every maker of magnetos supplies machines to run either clockwise or anti-clockwise **when viewed from drive end.**

A glance at the illustrations showing the contact breaker (page 298) will show that the breaker arm should be actuated from one direction only. Any magneto can, of course, run backward without doing any damage to its parts, and frequently has to when backfiring occurs at starting, but for making a spark it is desirable to run in one direction only, as given by manufacturers.

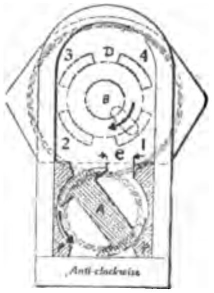


Fig. 2. Setting the Bosch Dual Magneto, when running "anti-clockwise"

****When a magneto is assembled the cam and contact breaker are set in the correct relative position.** The "break" of the primary current is made to occur when the "cheeks" or segmental-shaped sides of the iron armature almost bridge the gap of the top and bottom of the magnet poles. The position is not quite symmetrical, but the "maximum" or most favorable position is slightly in advance, in direction of rotation of a vertical line through the center of the magnets and armature, as shown in figs. 2.

It will be found in most types of magnetos that the contact rocker **has full retardation point**; that is, the actual break between the platinums agreeing with the armature in this position of **maximum** effect.

The reason is this: owing to the necessarily slow rate at which the magneto can be driven for starting, and as the spark

Dyke's four and six cylinder engine working models of a gasoline engine explain the relation of the position of pistons, valves, cams and magneto, as well as the principle of engine and how the magneto is attached and operated by engine.

---

*Figs. 2 as viewed from driving end of magneto. **The Eisemann dual system is similar to the Bosch dual. **See pages 309, 301 and 290. †See page 922 for diagram of wiring of model RL magneto.

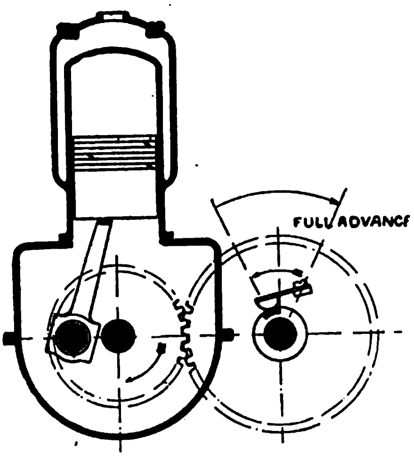


Fig. 1.—Spark fully advanced.

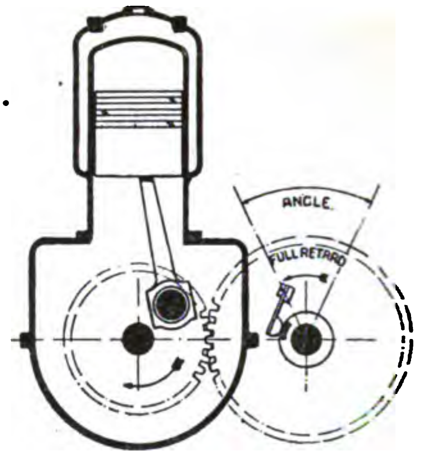


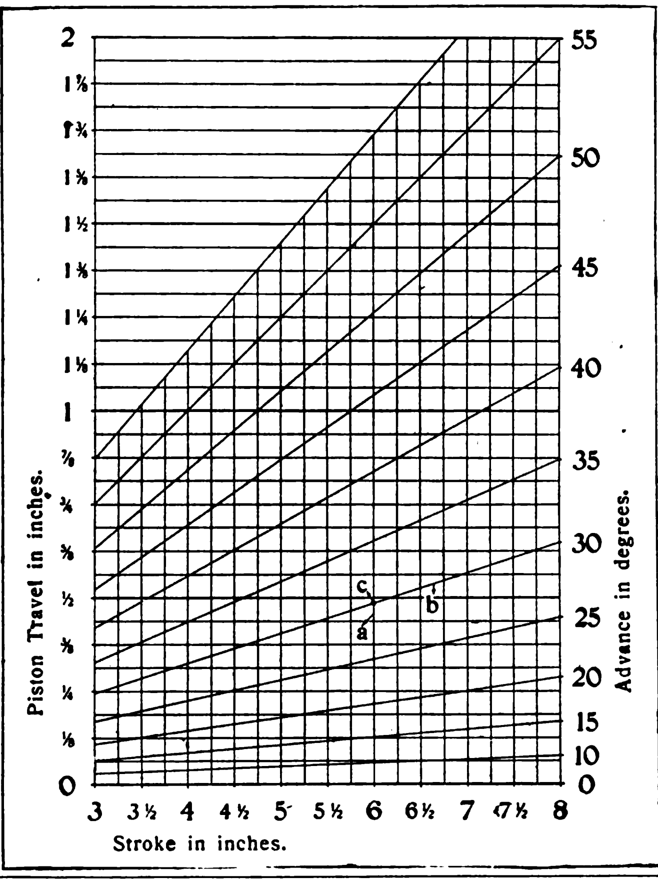
Fig. 2.—Spark fully retarded.

Fig. 1. The object of this illustration is to explain the meaning of advance of spark. Note the time of spark is occurring a considerable distance before the piston is at the top of its compression stroke. This would be causing the spark to occur at full advanced position.

Fig. 2. Note the contact point on commutator has been retarded or moved in the direction of rotation, therefore the spark will not occur until the piston has passed up on its compression stroke and part of the way down on its power stroke.

On a magneto, the contact breaker or interrupter instead of a commutator is advanced and retarded, but the principle is the same.

The angle of movement of contact maker is shown to make the principle clear, considerably greater than obtains in practice.



The relation of the piston travel to the rotation of the crank shaft depends on the stroke and the length of the connecting rod.

The piston travel of an engine is easily determined, and the determining of the rotation of the crank shaft in degrees, corresponding to any desired piston travel, may be ascertained from the accompanying diagram. In this diagram the relation between the crank and the connecting rod length is as 1:4.5.

In the diagram the vertical lines numbered at the bottom give the stroke of the engine in inches, the rotation of the crank shaft in degrees being indicated by the slanting lines and the figures at the right.

The figures on the left, and the horizontal lines indicate the piston travel in inches.

As an example in the use of the diagram, it may be desired to find the piston travel for an advance of 30° on a motor of 6 inches stroke. The vertical line for the desired stroke may be indentified by the figures at the bottom of the diagram, and this vertical line may be followed upward until it cuts the diagonal line indicating the desired number of degrees, which is 30° in the present case.

The horizontal line nearest this point, should be followed to the left, until it meets the diagonal line, and this followed to the left-hand side. In the present instance it will be seen to indicate about ¼ inch. This gives the advance in inches, corresponding to 30°.

CHART NO. 151—Diagram for Determining the Advance in "Inches" or fraction thereof, to Set Piston when stroke is known and when the Time to Set the Spark is Expressed in "Degrees."

See foot note, page 311 for meaning of 1:4.5.

has to be slightly retarded to prevent a backfire occurring, the most use must be made of the maximum position, otherwise there would be too weak a spark produced to ignite the gas.

On the other hand, it must follow that on advancing the contact breaker for normal running, the "break" will be occurring at proportionately less favorable positions of magnetic effect; but another factor comes into play, which largely compensates for this, viz., the increasing speed of the armature.

In practice this works well, and prevents the generation of excessively strong sparks, which are not required, and only serve to fuse up the electrodes of the plug.

The spark is made sufficiently powerful for starting on, by the use of strong field magnets and breaking circuit in the most favorable position of the armature's rotation.

After starting, the intensity of the spark will increase as the speed increases, but it will never reach an excessive value, by reason of the advance of the contact maker timing the break before the maximum position.

The "breaking" distance between the platinums should never exceed 1-64 inch. The amount of range provided for advancing and retarding, is greater on some magnetos than others; an average range is from 22 to 35 degrees.

No hard-and-fast rule can be given as to the best piston positions corresponding to full advance and retardation; but in general, a trial setting as per the average plan, fig. 1, chart 150A might be tried, in which the gear wheels are meshed so that, with the contact breaker fully retarded, the piston is on top of the compression stroke.

If it is found that the contact breaker cannot be properly retarded at slow speeds, without the engine tending to knock, another setting must be made, and the piston moved farther on the firing stroke.

After a few trials and careful noting of the pull of the engine, the best setting for the particular conditions will be attained.

Setting Time of Spark—Miscellaneous Systems.

The old style coil ignition system, with "vibrators and commutators" require a greater advance than magneto ignition. The reason for this is due to the time required for contact of commutator, contact of vibrator and a possible loss of time for the vibrator to start operating.

Quite often the trembler blade of a vibrator coil is adjusted so that the vibration is slow to take place, this will cause spark to occur too late. The trembler blades also occasionally stick, thereby causing missing.

The vibrator coil also gives a waste of current because the ordinary vibrator coil produces from four to ten weak sparks for each power impulse, whereas one good strong hot spark would fire quicker and save current. An illustrated example is shown on page 250.

The usual method is to place the spark lever midway between advance and retard position, so that it will have half of the motion to advance half to retard (see fig. 4, chart 152).

This should allow ample range for retarding and advancing, but a trial should be made with the engine running, and a note made as to how the speed responds to the advance and retard movement and variation in setting made as found necessary.

The amount of advance that can be given to any engine depends on certain variable factors. It is not possible to have as much advance on the ignition when the engine is running under a load as when it is running light and at a fast rate.

Note the setting of the spark on the Ford, fig. 2, chart 152, as an example of a coil with vibrator setting.

***Timing the low tension magneto, with make and break type of igniter:** The armature of the magneto must be positively driven off the engine by means of chain or gear wheels. On engines with cranks at 180 degrees, where the ignition has to take place at 90 degrees relative to the cam shaft, the armature has to be driven at crank shaft speed.

In the low tension "make and break" system the contact breaker is not fitted on the magneto; a connection from the outer end of the armature winding joins up to the terminal of the hammer-break device inside the cylinder.

The general practice when timing (see chart 152), fig. 5 is to arrange for the mechanism of the break to "trip" when the piston is just completing the compression stroke or a little earlier; say ⅛ of an inch (or an amount determined by experiment to give the best results), the armature being, as in the case of the high tension system, in "maximum" position.

Dyke's working model of a magneto explains the principle of a magneto. The armature is shown in section as well as the drive gears. The reader can easily figure the relation of speed of cam, armature and distributor, also actually practice setting the magneto with this model.

*When setting time of spark on a stationary engine, the spark is set to occur, when retarded, slightly after compression stroke to prevent kicking back. This type of engine is usually equipped with a "make and break" igniter system.

Timing the Ignition of the Modern Battery and Coil System.

This heading would comprise such systems as the **Atwater Kent**, page 248; **Connecticut**, page 252; **Delco**, pages 377, 390; **Westinghouse**, page 251; **Bosch**, page 253, and similar systems. By referring to the pages the ignition timing is given. (see page 317).

Timing Commutator and Vibrator Coil System.

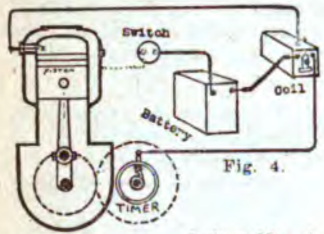


Fig. 4.

Fig. 4: Owing to the lag and inertia of a coil trembler considerable range of advance is required to obtain the spark at the most effective position of the piston. (This system is seldom used—see page 215).

(1)—place piston on top of compression stroke; (2) place spark lever in center position of quadrant (SL); (3)—set contact on commutator so it will make contact with No. 1 cylinder.

This will allow for a range of advance and retard in either direction from the center.

Timing Ignition of the Ford.

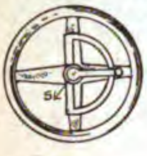


Fig. 2: The **Ford ignition timing is as follows: (1st)**—bring No. 1 piston to top of compression stroke—then move piston down **after top,** about ⅛ inch; **(2nd)**—place spark lever on steering wheel at full **retarded** position (see page 771 showing position of spark lever to retard, which would be up); **(3rd)**—place **roller** of commutator, on No. 1 segment so it will just start to make contact with segment; **(5th)**—the firing order is **1, 2, 4, 3,** therefore see that connections from commutator terminals are made accordingly; **(6th)**—set **spark plug gap** $1/32$ inch or slightly less.

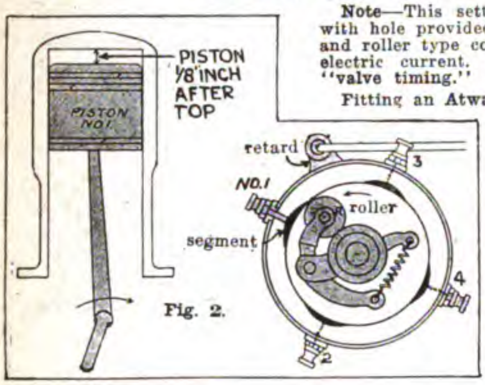


Fig. 2.

Note—This setting ought to bring the roller on cam shaft in line with hole provided for it. The Ford uses a multiple type vibrator coil and roller type commutator. A fly wheel magneto (page 265) supplies electric current. See also, pages 803, 804, 805 and page 785 for "valve timing."

Fitting an Atwater-Kent system to a Ford (pages 248 and 810); set piston ¼ inch down after top—on power stroke—with interrupter retarded. This is possible, because (AK) has a wider range of advance and retard. See also page 810.

Timing "Make and Break" Ignition.

Fig. 5.—Illustrates the principle of timing a low tension magneto using a "make and break" ignition.

The armature is in one of the maximum positions just as the piston is completing the compression stroke and "break" or "igniter" mechanism has just tripped or broken circuit. (see text, page 315). This system is seldom used.

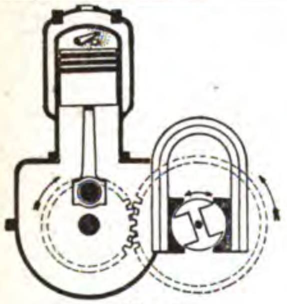


Fig. 5.

Checking Ignition Timing.

When gears are disengaged, which drive magneto or timer be sure they are marked—as indicated in figs. 15 and 16. When connecting high tension wires—first learn the firing order (see page 120 how to tell by position of cams) and then connect as explained on page 296. Remember the distributor on a magneto revolves opposite to armature. For instance, see fig. 16; crank gear revolves to left (standing in rear); idle gear to right; magneto gear to left and distributor to right.

In fig. 16 the rotor or distributor turns in a clockwise (right-hand) direction so that it next will make contact with the stationary segment No. 2. As the engine fires 1, 3, 4, 2, the cable No. 2 should lead to No. 3 cylinder, No. 3 to No. 4 cylinder and cable No. 4 to No. 2 cylinder. (see page 296.)

Remeshing Timing Gears.

Fig. 15. (Overland engine and behind the lower pulley of the cooling fan, there are four spiral gears. the crank-shaft gear, the cam-shaft gear, an idler and the magneto gear. When these gears have been taken out assemble as follows:

Turn the flywheel until pistons one and four are on upper dead center, with number one ready to fire. On keying the cam-shaft gear and the crank-shaft gear to their shafts, the figure 1 on the former will mesh with the figure 1 on the latter, as shown in fig. 15. Now replace the idler gear so that the figure 2 on crank-shaft gear and figure 2 on the idler also come in mesh. Finally, mesh the figure 3 on the magneto gear with figure 3 on the idler gear, and the proper meshing of the gears will have been accomplished (see pages 112, 113, 89).

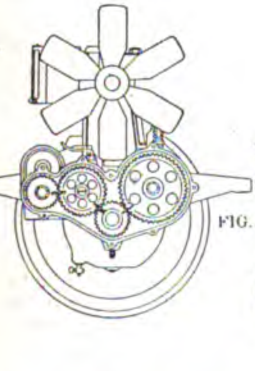


FIG. 15

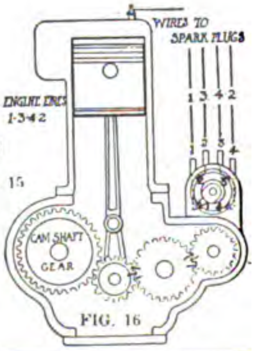


FIG. 16

CHART NO. 152—Setting the Time of Spark on Coil Systems of Ignition. Timing Ignition of the Ford; Checking Magneto Ignition Timing. Re-meshing Timing Gears. See also, pages 112 and 113.

No variable advance or retardation is as a rule provided, reliance being placed on the proportionately greater volume or intensity of the spark as the speed increases, thus causing more rapid combustion.

The factors to be determined in timing with low tension, are the time of break, piston position, and armature position.

Simple method to aid in setting the "make and break" igniter. The former can be very accurately set by the aid of an ordinary electric bell and battery, a simple circuit formed through the "break" device on engine. When the break hammer is in contact with the insulated stud the bell will ring; but, on revolving the fly wheel, the moment the circuit is broken between hammer and stud the bell will cease to ring.

If, as should be the case, the fly wheel is marked off to indicate piston position, a very delicate adjustment can be made. It is important in adjusting the hammer-break to obtain a break of sufficient length, but not an excessive amount. This amount varies according to the type of break mechanism used. An average distance would be about 3-16ths inch, with a maximum distance of one-eighth between the hammer or tappet and insulated stud. (see pages 215 to 217 and 260.)

Setting the Time of Spark on the Atwater-Kent and Delco Battery, Coil and Timer System of Ignition.

The time for setting the spark to occur when using the Atwater-Kent, Delco and similar battery and coil systems differs only slightly from the time the spark should occur with a magneto.

The method however differs as there is no armature to set. Instead, the timer shaft is set as explained under the timing of the spark as per page 250.

The Delco ignition is set in the same manner, see page 390. Also see Remy, page 318, 251 and Connecticut, pages 251, 364, 358.

How to Determine the Setting of Time of Spark on Leading Cars.

First turn to the index and find "Specifications of Leading Cars;" turn to the charts and find the make of ignition system being used. If it says "Bosch," then turn to the explanation in this instruction on setting the Bosch magneto. If it says "Atwater-Kent," or "Delco," turn to index for "Delco" or "Atwater-Kent" ignition system and you will find the timing instruction.

This same rule applies to **timing the valves, carburetion and other adjustments.**

Verifying the Ignition Timing.

It occasionally happens that cars turned out of the factory hurriedly to meet pressure of orders, are not as well adjusted in the setting of the ignition timing as they might be, with the result that the car may not prove an easy starter.

In fact, the writer had occasion to locate a trouble of this kind. The nature of the trouble was irregular firing and knocking when running slow. When running fast the trouble disappeared, but in taking a steep hill the engine would slow down, and right where a retardation of spark was necessary, the trouble would make itself manifest. The ignition was a low tension magneto used in connection with a high tension coil.

The cause of the trouble was found to be that the magneto had been set for the spark to occur too far before the piston was on top of compression stroke when spark lever was fully retarded—in other words, it was set too far advanced.

The result was, when running slow, the spark would occur and combustion take place before piston reached the top of compression stroke, hence the pound.

By remeshing the gears driving magneto, so the spark occurred when piston was on top of compression stroke, with full retard position of breaker housing, and points of breaker just separating at that time, this allowed the combustion to take place a little later. The trouble then disappeared.

Testing Ignition Advance.

*If the ignition is suspected of being set too far advanced, then test as follows:

(1) **Place No. 1 piston on top of compression or its firing stroke.** This can be found, by following out the wires and noting when cylinder to be tested will fire.

(2) **Place breaker box in "retarded"** position.

(3) **Note if the breaker box points are just separating when piston is on top.** If so, the setting is about right for magneto.

If, however, the points have already separated, then it is likely there is too much "advance," the amount being determined by the distance the spark occurred before top.

If a vibrator coil system, then the contact on segment ought to be made when piston is say, ⅛ inch over top of compression stroke with retard spark lever.

If a change is made of the setting, then a trial should be made with the engine running, and a note made as to how the speed responds to the advance and retard movement, and variation in setting made if found necessary.

***Understand, this rule must not be followed altogether. As some manufacturers set at full retard, slightly before top.**

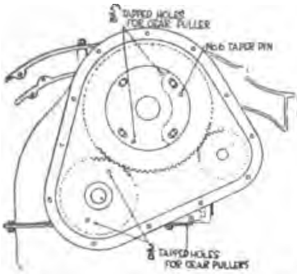


Fig. 2—Diagram showing location of tapped holes in camshaft and crankshaft gear

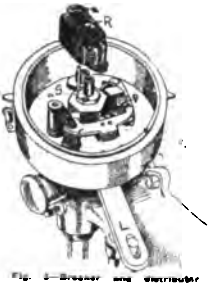


Fig. 3—Breaker and distributor mechanism. The brush is readily removed

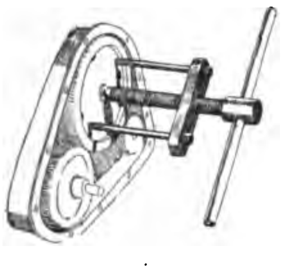


Fig. 1—In removing the camshaft or crankshaft gear two carriage bolts which are part of the puller are screwed into tapped holes in the web of the gear

Disassembling.

(1.) Remove hood.

(2.) Drain radiator.

(3.) Remove radiator.

(4.) Remove fan pulley and sleeve.

(5.) Remove all bolts holding gear cover to engine.

(6.) Pry case free, taking care not to destroy the cork gasket. This should stick to the cover and be removed with it.

Removing Timing Gears: These gears need only be removed when to be replaced or a general overhauling of the engine, fig. 2.

(1.) Remove .plunger on springs in gear shaft ends.

(2.) Remove inspection hole cover on flywheel and crank engine until 1-6-IN-O is at the top. This point can be felt by holding a file through the hole, with the point resting on the engine side of the flywheel face, and slowly cranking the engine. A hole is drilled in the flywheel at this point and the file will drop into the hole.

(3.) Mark gear faces so that they may be returned to the same position. (This is not essential if new gears are to be installed, but for ordinary overhauling will facilitate the assembly.)

(4.) Remove wires locking cam-shaft gear retaining bolts and unscrew bolts.

(5.) Remove dowel plate.

(6.) No puller is required to remove this gear, as each side of the gear is drilled and tapped 5/16 in., permitting two cap screws to be used to force the gear from the flange. The gear MUST be removed evenly.

(7.) Use the puller shown in Fig. 1 to remove the crankshaft gear.

(8.) Remove bonnet base strip on generator side.

(9.) Remove cotter pin and nut holding generator drive gear on its shaft.

(10.) Remove timer control rod and spring.

(11.) Disconnect wire at rear of generator.

(12.) Disconnect universal coupling.

(13.) Unbolt generator from base and lift generator off. (The shims should be marked and kept so they may be returned to the same position.)

(14.) Remove wiring from timer and plugs. Mark so that they may be returned.

(15.) Free timer from engine and remove, noting position of distributer brush, so that the timer may be replaced in the same position.

(16.) Remove the screw on timer drive shaft bearing plate, freeing timer drive shaft.

(17.) Remove screws on rear bearing plate.

(18.) Drive generator drive shaft out of gear. (It is poor practice to pull this gear off.)

(19.) Inspect all parts for wear, clean thoroughly and provide new parts where necessary.

The Assembly

(1.) Replace generator drive shaft in housing and drive the gear back onto it.

(2.) Replace crankshaft gear.

(3.) Adjust valve tappets so that they have .002 in. clearance between tappet and valve stem. The camshaft may be turned from the front to do this.

(4.) See that the point 1-6-IN-O is still at the center of the inspection hole in the flywheel case.

(5.) Turn camshaft counter clockwise until the inlet valve of number 1 cylinder starts to open. This can best be felt by placing a screwdriver in the slot in the valve, as in grinding. By turning the valve back and forth the instant it starts to open may be felt.

(6.) Press camshaft gear in position with the teeth so meshing that the retaining bolts stand in the center of the adjusting slots.

(7.) Replace retaining nuts on camshaft gear and bring them up so they pinch the gear onto the flange.

(8.) Turn flywheel backward about one-eighth turn and then back in direction of rotation, at the same time turning the inlet valve of No. 1 cylinder with a screwdriver.

(9.) Stop turning the instant the inlet valve starts to open.

(10.) Note whether point 1-6-IN-O is directly beneath the inspection hole in the flywheel case.

(11.) If it has not yet reached this point, using a drift, drive the flange nuts on the camshaft gear back in a clockwise direction twice the angular distance that the point 1-6-IN-O must go to reach the vertical.

(12.) If it is past this point, drive gear in opposite direction in a similar manner.

(13.) Check timing for No. 6 cylinder in same manner.

(14.) If dowel pin holes in gear and flange do not line up, drill new holes and replace strap.

(15.) Tighten bolts and lock with wire.

(16,) Replace timer gears and generator taking care not to draw the bearings too tight.

(17.) Set engine on 1-6-IN-O with inlet valve of No. 1 cylinder just opening.

(18.) Set distributing brush on timer to connect with No. 6 terminal, or spark plug wire.

(19.) Set timer in retarded position.

(20.) Set hexagonal cam on breaker so that the points are just breaking, Fig. 3.

(21.) Lock in position with lock nut.

(22.) Adjust breaker points to about .015 in. clearance, and lock adjusting nuts in position.

(23.) Check adjustment of ignition. An allowance of 1 in. late is permissible.

(24.) Replace timing gear cover, making sure that end thrust plungers and springs are in place, and that cork packings are not broken. This should be set in shellac on the case side only.

(25.) Replace fan pulley, fan belt and fan.

(26.) Replace bonnet base strip.

(27.) Replace radiator and hose connections, making sure that all connections are tight. Common rubber cement should be used on all joints.

(28.) Replace hood, fill radiator.

(Also see page 251.)

CHART NO. 153—An Example of Ignition Timing (Remy) and Valve Timing on the Chalmers 35—Incorporating a Method of Removing the Timing Gears—(Motor World)

*Spark Control and Overheating.

As few motorists really understand just how the power efficiency of an engine is affected by the spark timing, (which is generally under the control of the operator) the following may be of interest:

When a combustible mixture has been compressed in a cylinder by the rising piston and the spark occurs, a very small portion of the mixture in the immediate vicinity of the spark is ignited; and if the mixture is of the proper proportions and suitably compressed, the flame propagation throughout the entire combustion chamber will be rapid.

This is as it should be. When combustion takes place intensely heated gases are formed, which in their effort to occupy a larger volume of space exert great pressure on the walls of the combustion chamber and upon the piston head.

As a gas or gaseous mixture is compressed it becomes heated, and the greater the pressure the greater the heat.

If a mixture is of proper proportions, the greater the pressure the more readily will it ignite, and the greater the speed of flame propagation or combustion.

On the other hand as the pressure of a combustible mixture is reduced, it loses its heat, and its speed of ignition and combustion is also reduced.

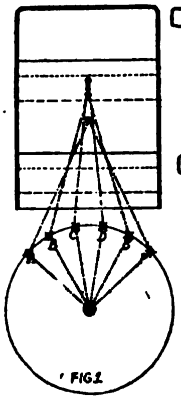


FIG. 1

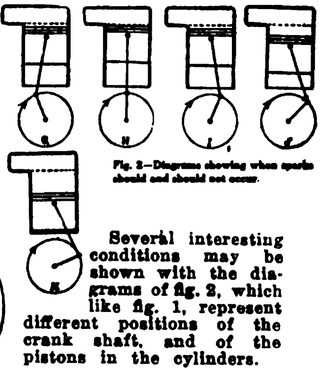


Fig. 2—Diagrams showing when sparks should and should not occur.

Several interesting conditions may be shown with the diagrams of fig. 2, which like fig. 1, represent different positions of the crank shaft, and of the pistons in the cylinders.

Thus it must be understood that to get the utmost efficiency out of a combustible charge it must be ignited at or near the point of maximum compression.

Let it be assumed that a car is being driven at a speed of about 30 miles per hour, and that the engine is necessarily turning over at a speed of about 1200 revolutions per minute, the spark lever advanced so that sparks occur when the piston is ascending as at (G).

Ignition we will assume, is complete at (H), and combustion at (I), at which point the maximum pressure of the expanding gases is being exerted.

Under these conditions the engine runs smoothly and cool.

Now by retarding the spark and advancing the throttle lever it is found that the speed of 30 miles an hour, still can be maintained.

The engine is generating the same amount of power, but with the spark retarded and the throttle advanced; but after about 30 minutes' running the radiator begins to steam and we see that the engine is overheated.

What is the cause? It is this: The spark is retarded so that now it occurs when the piston is at (I); compression is already reduced so that ignition is slower and is not complete until the piston is at (J), and combustion is still incomplete at (K).

The explosive mixture is now richer in fuel, so that more heat is given off than under the first mentioned condition; therefore, the expansive force is greater than before, so that the speed of the engine is the same, but note the area of wall surface of the cylinder at (K), which now is exposed to this more intense heat.

The water in the jackets not only has to take care of the heat absorbed by the walls of the combustion chamber, but also of an excessive amount absorbed by the cylinder walls.

Range of Spark Advance and Retard.

Fig. 1. Is a diagram showing the range of spark advance and retard representing different positions of a crank shaft and the relation of the piston in the cylinder at these different positions.

Referring to this diagram, if an engine is running at an extremely high rate of speed the spark might be advanced so as to occur in the cylinder when the throw of the crank shaft is ascending and at the point (A); thus combustion might be complete or so nearly complete by the time the throw reached the point (D), that a very strong pressure would be exerted upon the piston, which is as it should be.

If the engine were being subjected to an extremely hard pull, as in ascending a hill on high gear so that its speed is considerably reduced, and ignition were to take place at (A), combustion might be complete at (B) or (C), and the pressure or power-impluse on the piston head would tend to turn the crank shaft in a reverse direction.

If the car were traveling at a very low speed or if there were not sufficient momentum in the fly wheel or the car itself, the engine would be stalled, or killed, as the saying goes.

Of course, if the car or engine were traveling at a sufficiently high rate of speed to carry the crank and piston over this dead center, a large percentage of the power would be applied in the right direction, but considerable would be lost; there would be what is known as an **ignition knock**, and the strain on the bearings would be quite severe.

---

*See also page 308.

On the other hand, if the engine has been slowed down considerably under hard pull and the ignition is retarded so as to occur at about (C) or (D), combustion might be complete at about (E) or (F), or perhaps even a little farther down where the leverage on the crank shaft is greatest, and thus the greatest amount of the downward pressure on the piston is utilized.

It must be remembered that the **greatest power** is dependent upon the momentum or torque of the fly wheel.

An engine always should be run with the spark advanced as far as possible without causing it to knock or lose power, and it will overheat, if caused to run for any great length of time with a retarded spark.

Finding Position of the Piston.

In the previous matter we have mentioned about placing the piston on top of compression stroke. To tell when piston is on top of compression stroke is explained below.

Usually a mark is placed on fly wheel to indicate when piston is at top. For instance, if a four cylinder engine, a mark will likely be on fly wheel as "D C 1-4," meaning "dead center up 1 & 4" or one and four pistons are at top of stroke. If a six cylinder it would probably appear as "D C 1-6 up," meaning pistons 1 & 6 on top. Or mark may be, "1-4 up" or "1-6 up," meaning the same.

It is necessary to find, however, just what stroke the pistons 1 & 4 or 1 & 6 are up on, therefore watch the valves; on compression stroke, both valves should be closed. Or watch when inlet valve opens—piston is then starting down on suction, therefore the next (up stroke) must be "compression."

The fly wheel will then have to be turned until this mark is centered with an indicator mark usually on cylinder or some central point, see pages 102 and 104.

From this point the fly wheel is turned to the right, to place piston before top of stroke, or to left, to place piston after the top of compression stroke. This rule applies when standing behind fly wheel, when fly wheel is on rear of engine.

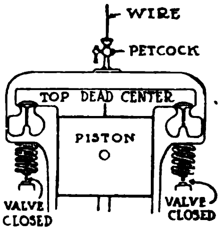
The exact point, however, when the piston is on top of compression stroke is rather difficult to determine.

If engine happens to be a "T" head motor with a compression cock in the center, then it is easy to find when piston is on top of compression stroke by placing a wire or bicycle spoke through the pet cock and turn the engine over; when the wire rises to its highest point the piston is on top of dead center.

On a four cylinder engine, when No. 1 piston is on top, No. 4 is on top also. On a six, when No. 1 is on top No. 6 piston is also on top.

Therefore, to find when this particular piston you propose to work from, is on compression stroke; watch the valves. Both valves will be closed. The exhaust cam would be at a position where it would open the exhaust valve after one movement or stroke—this stroke being the power stroke.

If cylinder is of the "L" head type it may not be possible to get a wire into the cylinder. In this case open compression cock and place your finger over it, have some one crank engine slowly until you feel compression; let this escape gradually. When the gas has ceased escaping, the piston is at or near, top dead center. The compression stroke is found by watching when both valves are closed.



This plan is uncertain however, and the best plan is to remove lower crank case and turn the crank until the connecting rod and crank shaft throws are straight up and down, in line; at the same time watch the valves as mentioned above.

This procedure however, is not necessary if there are marks on the fly wheel to indicate just when pistons are on dead center.

To determine the end of the compression stroke in any cylinder (Overland as example); turn the crank until the exhaust valve in that cylinder, which is the one directly beneath the priming cup, has just reached its seat; and then turn the fly wheel approximately one revolution, stopping when the mark 1-4 UP (or 2-3 UP) is at its highest position and in line with the guide mark on the back end of the crank case. Another method is to turn the engine while the hand is held over the open priming cup and identify the compression stroke by the escape of air. After the fly wheel is in the proper position install the timing unit as directed.

INSTRUCTION No. 25.

ENGINE STARTERS: Ignition or Switch. Primer and Ignition. Compressed Air. Acetylene Gas. Gasoline and Air. Mechanical Starters. Parts of an Electric Starting Motor.

The first form of self-starter was the ignition starter. It is still used but to no great extent in connection with the priming systems and gas systems of starting as explained in chart 154. A special form of switch however, is sometimes provided which causes a spark to occur in all cylinders simultaneously.

It is posible to start any engine ocasionally on the switch, if the cylinder in which the spark is made at the time, happens to have a charge of gas and the ignition is a battery and coil system, either as an auxiliary or regular system. If, however, the magneto system and breaker is used in connection with a non-vibrating coil, then the chance of obtaining the spark is not so great. The breaker points will not permit the opening and closing of circuit when engine is idle.

Therefore a special connection is usually provided on the coil in the form of a button switch. This applies to four or six cylinder engines. The principle is this; there is always a certain amount of unexploded gas remaining in one of the cylinders when engine stops, especially if driver has taken the precaution to open his throttle before engine stops. Therefore, if a spark occurs in the cylinder this unexploded gas will combust and give enough momentum to start the engine.

As stated above, if a coil system is used, the switch can be thrown on and a quick movement of the spark lever, its full length will cause contact to be made on the timer or commutator, thereby causing a spark in one of the cylinders.

Naturally the cylinders must be in good condition. The piston rings must be tight so the compression will not be lost by leakage. When stopping the engine the throttle ought to be opened part way so as to admit a full charge of gas to the cylinders, in order to make starting easier. The engine must of course be speeded up, but by holding the clutch out.

The priming method of starting was the next method used. Instead of depending on the pistons to draw in a charge of gas, a special pump was devised as shown in fig. 3, chart 154. This pump forced a charge of carbureted gas into the cylinder.

The acetylene gas idea of starting developed from both of these systems. The Presto-lite Co. worked out a very satisfactory system for starting as explained in fig. 5, chart 154. This system also employed a special electric connection for igniting the gas.

The compressed air system was first used by taking the pressure from the exhaust, storing it into a tank, then distributing it to the cylinders. The compressed air starter is divided in two classes; the type which uses a pump, operated mechanically from the engine to store fresh air into the air tank, as shown in fig. 4, chart 154. The other type; the exhaust gases are stored into a tank.

The Christensen gasoline and air starter, fig. 6, page 322, is used on aeronautical engines, as the Thomas, Sturtevant, Roberts, Duesenberg, Hall-Scott, Curtiss, Wisconsin and others. Also motor boats, trucks, tractors and automobiles.

Principle: this starter does not crank the engine but starts it as follows: The engine when running, uses gasoline and air, properly mixed, as its fuel. When not running it cannot be started ordinarily only by cranking by hand or some other starter. The Christensen starter supplies this mixture to the engine in ready-made form, under compression, to each of the cylinders in firing order so that the engine is started on the first touch of the button.

The parts are shown in fig. 6 and consists of the **compressor;** a **clutch** for engaging and disengaging same; a **carburetor chamber** (independent from engine carburetor) and a **distributor,** timed with the firing order of the engine; a **control valve,** which is used for starting the engine and for engaging the air compressor; a **tank** for holding the **air** and a **gauge** telling how much air the tank contains.

Into each engine cylinder a **starter check valve is screwed,** (usually in the priming cup opening) and a **pipe** runs from the check valves to the distributor.

Method of attaching: The starter unit is usually driven by Oldham coupling from the crank shaft or cam shaft, and is mounted in the most convenient place. (The Christensen Engineering Co., Milwaukee, Wisconsin.)

The mechanical starter is made in many and varied forms, one being shown in chart 154.

Therefore, we have the several classes of self-starters classified as follows: **Ignition or switch starter; primer and ignition; acetylene gas; compressed air; gasoline and air; mechanical** and **electric.**

Electric Starter.

The electric starting motor has many advantages over other systems, in that the motor is easily applied and manipulated. The source of electric supply is derived from a storage battery which is kept recharged by an electric generator (dynamo).

The electric starter is the system in general use and will be treated in the next instruction.

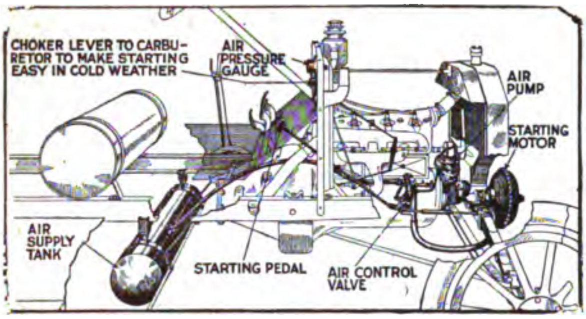


Fig. 4.—Compressed air starter: The Stewart starter for the Ford, cranks the engine from the front end of the crank shaft in exactly the same manner as it would be cranked by hand. To start the engine, it is only necessary to press the pedal which is installed on the foot-board.

The starter motor, or cranking unit, is an air-tight chamber, circular in form and replaces the crank handle.

Passing through this is a shaft which engages the engine shaft, the same as the crank handle formerly did. Within the cylinder is a stationary head; also a revolving valve.

This valve is attached to a collar through which the starter shaft passes. In operation, the charge of air is admitted into the starter motor at a point between the stationary head and the revolving valve. This air pressure forces the revolving valve to make almost one complete revolution.

Inside of the collar, attached to the revolving valve is a pawl which engages the grooves or teeth in the starter shaft. A "driving" clutch is attached to the end of this starter shaft.

A "driven" clutch is installed on the end of the engine crank shaft.

The driving clutch engages with the driven clutch in the same manner as formerly, when the car was started by the old crank handle. (Stewart Speedometer Co., Chicago, Ill.)

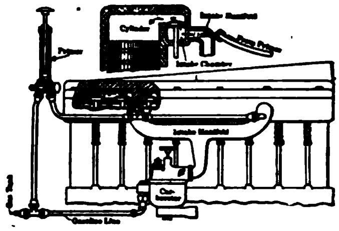


Fig. 3.—A primer starter: Cylinder primers are all operated very much along the same lines, the fuel being injected into either the cylinders themselves through special priming cocks or into the intake manifold. A hand operated pump is usually used to draw the gasoline from the supply tank to the feed pipe. The gasoline is brought into the primer cylinder from the carburetor supply pipe. It is then forced into the intake manifold through a special form of spray nozzle. An upward stroke of the handle fills the primer cylinder, and a downward stroke forces it into the valve chambers of the engine. With all priming systems it is necessary to have a spark at the correct time—see text, page 282 for "starting on the switch."

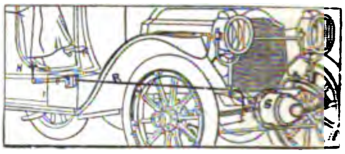


Fig. 2.—A mechanical starter: This device (S) is attached to the front of the car in place of the ordinary starting crank. It is about the size of an ordinary automobile headlight and looks like one reversed. There are two powerful springs in the device which are released by a very slight pressure on a pedal (H) which is located near the drivers seat. (American Ever Ready Works, Long Island City, N. Y.)

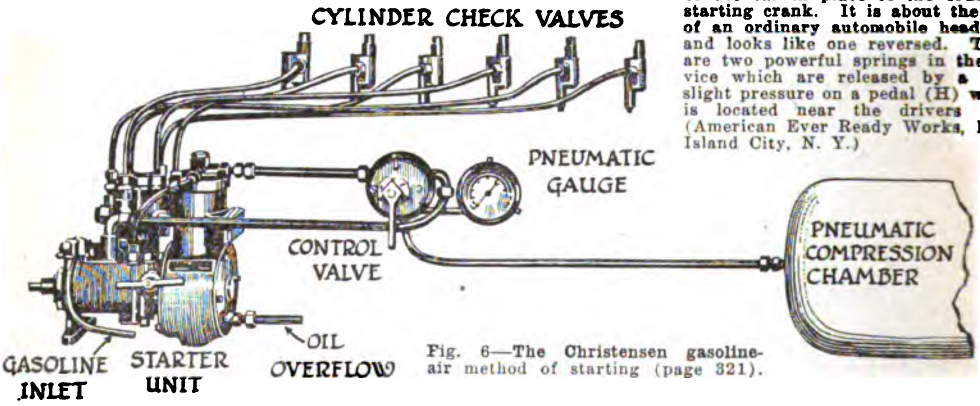
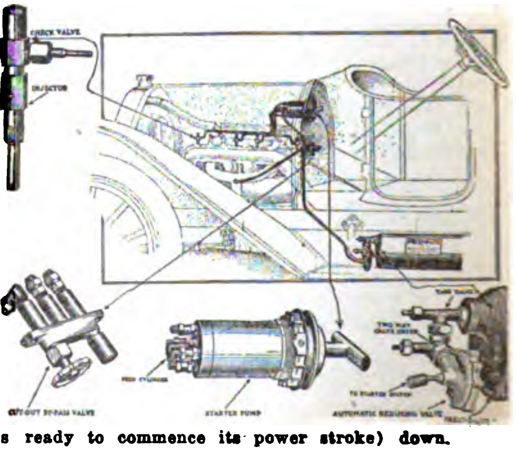


Fig. 6—The Christensen gasoline-air method of starting (page 321).

Fig. 5.—Gas starter: The Prestolite gas starter system permits the starting of the engine by the injection into each cylinder of a measured amount of prest-o-lite gas, which is exploded by pressing the button on the ignition switch. (See ignition starting, page 282.) The driver charges the cylinder with gas by making one or two movements of the handle, which is located on the dashboard. There is placed at the tank an automatic reducing valve, which reduces the pressure beyond the tank to two ounces. Whether the tank pressure be 150 or 250 pounds, the pressure in the lines can only be two ounces. On account of low pressure it is necessary that the gas be forced into the cylinders, as the cylinder compression is many times stronger than two ounces. This is accomplished by a pump which is placed on the dash in easy reach of the driver. In cold weather the driver can press a by-pass valve button and cause the gas to pass from the tank directly to the intake manifold. (Prest-o-lite Co., Indianapolis, Ind.)



Compressed gas tank was a type of starter formerly used on the Winton. Part of the exhaust gases from the engine was stored up in a tank, during the exhaust stroke. This gas was then used for pressure, to force the piston (which was ready to commence its power stroke) down.

HART NO. 154—Engine Starting Devices; Mechanical, Air, and Gas.

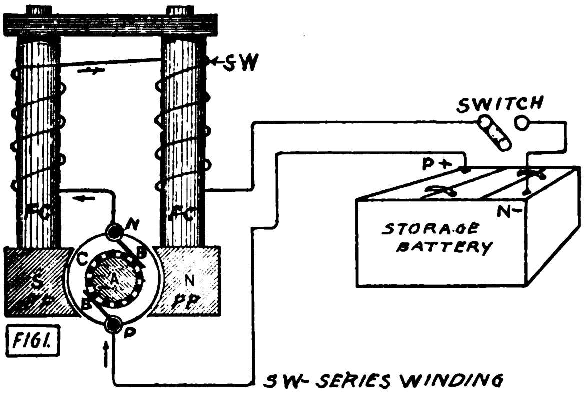


FIG1.

FC- FIELD CORE. A- ARMATURE. C- COMMUTATOR. B-BRUSH. PP- POLE PIECES.
SW.- SERIES WINDING ON FIELD CORE.

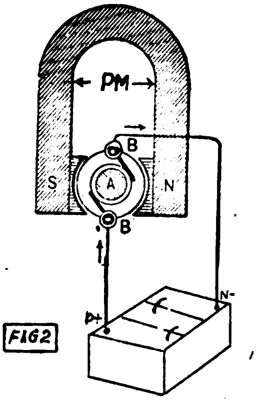


FIG2

PM.-PERMANENT MAGNETS

Starting Motor—Simplified.

Fig. 1.—A simple form of a series wound electric motor. The field cores are magnetized only when the current from the battery flows through the "series" wire winding, hence the term, "electro" magnetized field. The lines of force come out at "N" pole and pass in at "S" pole.

There are two poles or pole pieces (PP) to this motor, hence it is called a "bi-polar" motor. If it had four or more poles, as per chart 160A, it would be called a "multi-polar" type.

The winding on the field core is "series" wound, meaning, one part is connected with another in series; for instance, start at the battery and follow the current path and note the succession of parts connected.

A "permanent" magnetized field is shown in fig. 2. The magneto or fields (PM) are permanently magnetized.

The armature, however, on both machines is of the "drum" wound type—the armature shown on page 258, is a "shuttle" wound armature.

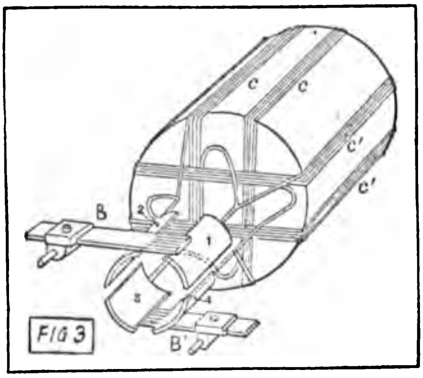


FIG 3

Fig. 3: A drum type of armature, used on all electric starting motors and generators for charging batteries.

The field however, can be "**electro**" or "**permanent**" magnet type.

B—brushes; commutator segments are 1, 2, 3, 4. There are two conductors from **each** coil. Note one end or conductor, of two different coils is connected to one commutator **segment**.

Armature—"Drum" Type.

Fig. 3.—On a drum armature, the coils are wound longitudinally over the surface of the armature core drum.

C—are the coils of wire, c^1 is the core, usually made of laminated iron. 1, 2, 3, and 4 are the commutator bars, or segments on which the brushes rest and carry the current to the armature coils. Each segment is insulated one from the other by mica. There are as many segments as there are coils of wire.

On a "shuttle" type of armature as shown in fig. 7, page 332, the winding is quite different—note the illustration.

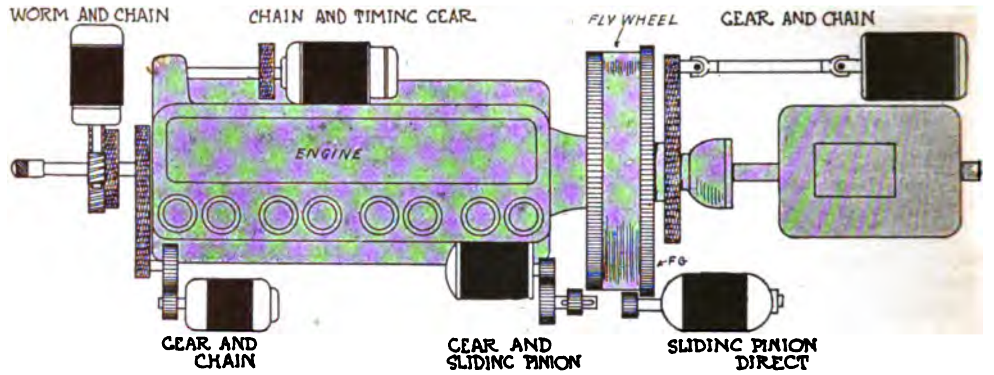
The parts of an armature are; core, coils or winding, shaft, copper commutator bars, mica insulators and the binding wires. (see fig. 4, page 330.)

The core is usually made of sheets of iron placed side by side and then turned on a lathe until round. Slots are then cut into the laminated core (L), to hold the armature coils.

Bands of fine brass wire, (BB), are then placed around the armature to hold the armature coils in place when revolving.

CHART NO. 158—Parts of an Electric Starting Motor.

Charts 155, 156, 157 omitted (error in numbering).



Automobile engine viewed from above, showing several of the extensively used methods of applying the electric starter

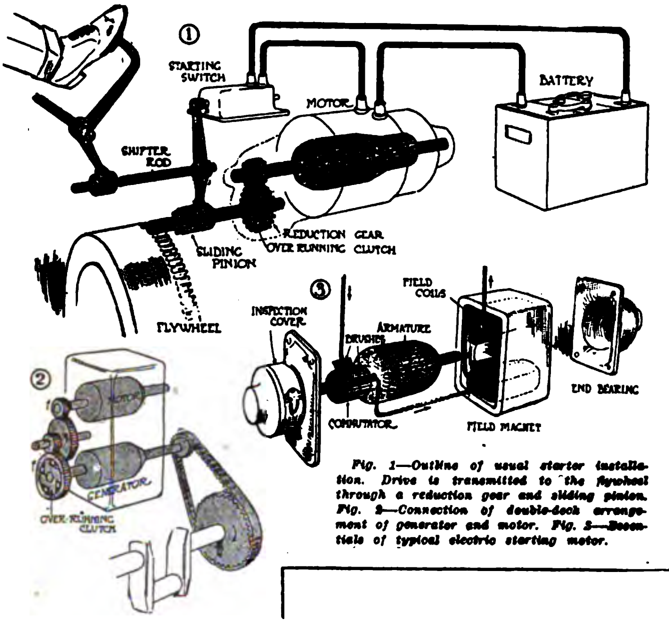


Fig. 1—Outline of usual starter installation. Drive is transmitted to the flywheel through a reduction gear and sliding pinion. Fig. 2—Connection of double-deck arrangement of generator and motor. Fig. 3—Essentials of typical electric starting motor.

Illustrating the various methods of applying the electric starting motor to engine.

When starting engine by chain or gears, there **must** be some form of **release,** so that the motor **will not** continue to run after engine is started. **This release** is usually in the **form** of a roller clutch or **gear** shift.

The method of **starting** through the **fly wheel is** the most popular **system.** Also see pages 326 and 331 for the Bendix starter.

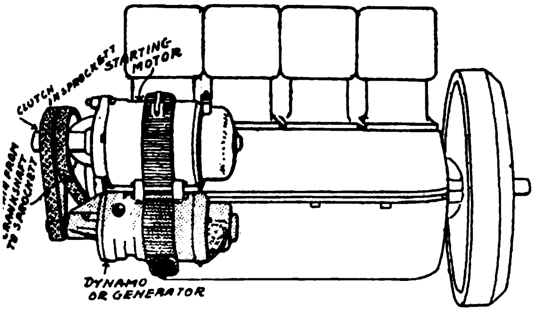


Fig. 8—Showing application of starting motor to crank shaft by chain and sprocket. Note clutch is in sprocket. Both chain and sprocket run with engine, but clutch in sprocket cuts out motor after engine is started.

This system formerly used by the Gray and Davis on the 1914 Overland.

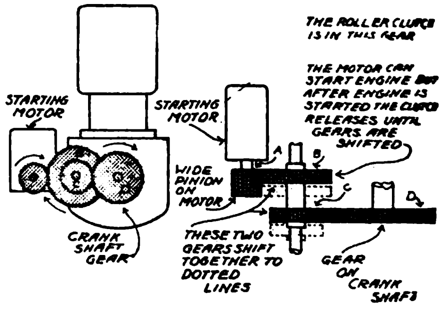

THE ROLLER CLUTCH IS IN THIS GEAR
THE MOTOR CAN START ENGINE BUT AFTER ENGINE IS STARTED THE CLUTCH RELEASES UNTIL GEARS ARE SHIFTED
STARTING MOTOR
STARTING MOTOR
A
B
C
D
WIDE PINION ON MOTOR
CRANK SHAFT GEAR
THESE TWO GEARS SHIFT TOGETHER TO DOTTED LINES
GEAR ON CRANK SHAFT

Fig. 7—Showing application of starting motor to crank shaft by gears. Note clutch is in B. The Westinghouse starting motor is connected in this manner on the Dorris car. A feature worth mentioning is that the gears are all out of mesh after motor serves its purpose. (see page 328.)

ART NO. 159—Application of the Electric Starting Motor to the Engine; through the **Fly Wheel, Transmission Shaft** and through the **Crank Shaft.** Note different methods of **each.**
e most popular method of drive is through the fly wheel using the Bendix Inertia gear shift method.

INSTRUCTION No. 26.

THE ELECTRIC STARTING MOTOR: Mechanical and Automatic Gear Shift Method Explained. Types of Motors. Starting Switches. Reduction Gears. The Rushmore Displacement Type or Automatic Electric Gear Shift. Bendix Inertia Gear Drive.

The electric starting motor is an electric device or motor for turning over the crank shaft of a gasoline engine.

The electric motor is a device for transforming electric power into mechanical power. The electric motor receives its electric current for its motion, from an electric storage battery. **The storage battery receives its charging current from an outside source or an electric generator,** usually run from the gasoline engine. Quite often this generator (also called a dynamo), is made a part of the starting motor, as will be explained later. (see instruction 27.)

***Parts of Electric Starting Motor.

Principle: To know the principle upon which an electric starting motor is constructed, it will be necessary to know the names of the parts.

The magnets or "field" cores (FC) (page 323) are either "electrically" magnetized or "permanently" magnetized.

When electric current is passed through the "coil" winding, on the "field" magnets, the latter are "**electro**" magnetized. They are "**permanently**" magnetized (PM), when the field magnets are of the type shown in fig. 2, chart 158.

The "electro" magnetized pole pieces may have two or more poles, one must be a north pole and the other a south pole, similar to a common horse shoe magnet. This is necessary in order that the magnetic lines of force from the pole pieces attract the magnetized coils on the armature.

When the current passes through the wire surrounding the soft iron field core, the pole pieces acquire magnetism. When the flow of current is stopped, then the pole pieces lose their magnetism. Hence it is termed an "electro" magnet.

The windings on electro magnets, can be wound three different ways, series; shunt; and compound. The winding shown in fig. 1 is called a "series" winding, and is usually of heavy coarse wire.

The "permanently" magnetized pole pieces, are shown in fig. 2. Wire is not wrapped around the field cores, but the magnets retain their magnetism permanently. One pole being "N" and the other "S" at all times.

The pole pieces (PP), at the lower end of the field cores, as shown in fig. 1, are the north and south poles of the magnetized field cores. The pole pieces are placed very close to the armature and are the parts between which the armature revolves.

The pole pieces in fig. 1, are called "bipolar" type, because there are two poles. When there are more than two pole pieces, as in fig. 1, chart 160A, it is called a "multi-polar" type.

The armature on an electric starting motor is the part which revolves between the pole pieces. There are several types of armatures, but for starting motors, and generators to recharge batteries and supply current for lights, the "**drum**" type, fig. 3, is generally used.

The "shuttle" type armature, fig. 7, chart 162 and fig. 1 chart 120, is used for magneto ignition. The shuttle type of armature. is used only on magneto type of magneto generators and generates an "alternating" current, being used principally for ignition.

The source of current from the storage battery, to operate the electric motor is "direct" current.

***The commutator on the armature,** passes the current **to** armature coils from brushes on the motor. On a generator it transmits the current **from armature.** It is the part placed on the end of armature on which the brushes rest and to which the terminals of the armature coils connect, as shown in fig. 3, chart 158, see also chart 161.

There are as many copper segments on the commutator as there are coils on the armature. (see fig. 3, page 323 and note connections of coils c^1 to commutator segments 1, 2, 3 and 4). The segments are insulated, from each other, with mica between.

**Commutator troubles usually arise from too much oil on the commutator, causing a coating to form across the insulation, between the insulated commutator segments.

†Brushes on starting motors are the parts (B), chart 161, and 3, page 324, resting on the commutator segments and which conduct the current to the commutator. They are usually made of copper, bronze or brass wire gauze and also metal graphite which contains copper. A great quantity of current passes through a starting motor brush.

There are usually as many brushes as there are field windings.

---

*Don't confuse the meaning of a commutator on an electric motor or generator with the commutator used for ignition, as shown in chart 106.

**See also pages 409, 404, 406, 331. †See foot note page 408 for generator brushes and starting motor troubles, also read foot note bottom of pages 407 and 405.

***To learn the fundamental principles of an electric motor and dynamo we recommend Swoopes' Lessons in Practical Electricity, see ad in back of book.

Mechanical Method of Starting Motor Gear Shift.

Position 1—when switch is at position (1), the starting motor switch is off and starting motor idle. (see fig. 6.)

Position 2—starting pedal is depressed slowly, this causes contact to be made at (P) with (P1), at which time resistance (R) is in the circuit causing armature to rotate slowly. This slow rotation allows pinion (J) to mesh easily with fly wheel.

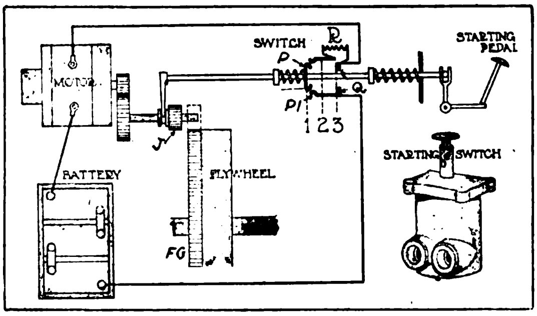


Fig. 6.—Mechanical method of applying starting motor to drive fly wheel.

Position 3—starting pedal is depressed fully. This causes (P) to make contact with (Q) at which point the resistance (R) is cut out and full voltage applied to starting motor terminals in order to crank the engine.

After engine is started, the starting pedal is released and the spring de-meshes the pinion (J) from flywheel gear (FG) and switch cuts-out and assumes position (1).

Note the reduction gear drive. Also the type of switch as it appears from outside view. This is one of the Westinghouse principles. This concern also supplies automatic and other principles—see page 338.

The Automatic Method of Starting Motor Gear Shift—The Bendix Principle, Also called the Inertia Gear Drive.

Fig. 8.—The Bendix "automatic" shifting pinion as used on a large percentage of the different makes of electric starting motors, also called the "inertia" gear shift, is pictured in fig. 8. This illustration is not exactly as it appears today, but explains the principle clearly (see page 331).

This type as used on the King (page 331), the reduction is 10½ to 1, or 12 tooth pinion on a 126 tooth gear on the fly wheel. The teeth are each 10 pitch and the starting motor will crank engine at speed of 150 to 200 r. p. m.

No arrangement of levers to slide the pinion into mesh nor any over-running clutch is required. It is only necessary to operate the switch of the motor, or press a switch button, and this can be done at the wrong time, i. e., when the engine is already running, without damage.

The parts are few and simple. The **armature shaft** has a screwed extension provided with an outer bearing (B), and carries the pinion (P).

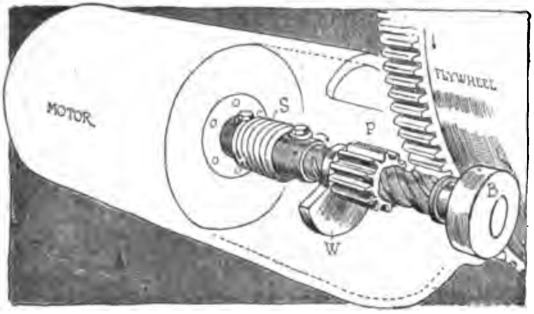


Fig. 8.—Automatic method of applying starting motor to drive fly wheel.

A weight (W) is solidly attached to the pinion and the latter is loose enough on the shaft to always occupy the position shown, with the weight underneath when the shaft is idle. The leading **screw** has a triple thread.

On starting the motor, inertia of the weight (W) causes it and the pinion to be carried quickly along the shaft into mesh with the teeth on the flywheel where it remains performing the operation of cranking until the engine commences to fire, when the direction of the drive is reversed, coming from the flywheel to the pinion, throwing out the pinion.

Action is easy to understand. But a query will naturally arise as to what would happen if the starting switch is not released and the motor continues spinning. It would seem that the pinion would again return and either get into mesh or continue chattering at the edges of the teeth. Neither happens. The pinion simply continues to rotate out of mesh until the switch is released. This is due to a secondary function of the weight (W). Immediately the pinion is thrown out from the flywheel the speed of the motor is such as to cause a binding of the pinion on its shaft due to the one-sided position of the weight. The action involved is that of the center of gravity of the weight attempting to get into the central plane of rotation of the pinion and the slight necessary looseness of the pinion on the shaft allows a temporary binding as a result.

The spring (S) is simply to ease the shock of starting by permitting a slight play between the motor shaft and the screwed extension. The teeth of both flywheel and pinion are beveled on the entering side for easy engagement. As shown the motor is geared by a single reduction to the engine, but the device is equally applicable to a double reduction.

HART NO. 160—Application of the Electric Starting Motor to Fly Wheel of Engine; the "Mechanical" and "Automatic" Method Explained.

Note:—The Bendix is also known as the Eclipse-Bendix.

Type of Electric Motors.

Although there are many different makes of electric starting motors, we have dealt only with the type in general use, which is the "series" wound field cores, with the "drum" type armature as explained in the charts.

We have given the names of the parts, also explained, that when the current from battery flows through the field coils, thence through the armature coils by the way of the brushes resting upon the commutator segments, which are connected with the armature coils, the armature, is then caused to revolve by magnetism, the pole pieces drawing the armature coils around. We will not attempt to explain why this armature is made to revolve, because this would necessitate a lengthy explanation and deep study of electrical engineering, not required by the average student.

Application of the Electric Starting Motor to the Engine.

The starting motor can drive the gasoline engine through the **fly wheel**, or by connection with the **crank shaft**, or drive through the **transmission shaft**.

The drive through the fly wheel is the most popular. There are two general methods used; (1) by gears as per A B C D, chart 160, which necessitates throwing the gear (J) in mesh with the fly wheel gear (FG) by **hand or foot.**

The other method is "automatic;" by pressing a button or foot switch the circuit is closed between the storage battery and starting motor. The "inertia" gear pinion (P) then automatically meshes with fly wheel gear as explained in chart 160 and 161A. This system is the most popular.

Another "automatic" method is where the gear is shifted "electrically," as in chart 161. This type is also called a "displacement" type of armature.

The drive through the crank or transmission shafts; can be by means of gears or chains as illustrated in chart 159.

After starting engine: In each instance some means must be employed to disengage the motor and engine after it is started, this is done by means of the **shifting gear** or **clutch.** See illustrations in charts 159 and 160.

Starting Switches.

The switch with resistance was formerly used with starting motor. This resistance prevents the full flow of current going to the motor, until armature is in motion. The resistance is in the form of German silver wire or other like substance which offers resistance to the flow of current. A further depression of switch, see fig. 6, chart 160, shows how the resistance (B) is cut out when switch contact (P) is in full contact with Q.

Switches for the "automatic gear shift" do not require resistance. See chart 160B.

*The Storage Battery.

The electric current is supplied to the starting motor from a storage battery. The **voltage** is usually 6 volts, but some systems use 12 to 18 volts, others 24 volts.

The voltage of storage battery can be ascertained, by counting the number of cells. For instance, if there are three cells then the battery is a six volt battery. If there are six cells it is a 12 volt battery. **Each cell gives two volts**—no matter how large or how small. (see instructions 32 and 32A.)

***The amperage or quantity of current consumed by a starting motor varies.** The average length of time the starting switch is down is about 10 seconds. Therefore, this great quantity of current being drawn from the battery it must have large heavy plates as well as large connections from one cell to the other.

Large wire for conducting the current to the motor is also necessary. (see pages 425 and 427.)

The average cranking current is 475 amperes when first starting—for say ½ of a second, then 180 amperes as the engine flywheel turns. The voltage of a charged battery when being used for starting, drops to approximately 5.75 volts.

(This test was made on a leading battery at a temperature of electrolyte of 86° F.) This of course varies according to compression, size of engine, etc.

The overload on the battery, it will be noted, is considerable, in fact, it is a temporary dead short-circuit for an instant, but being only momentary—a good battery will stand it. (see pages 427, 400 and 408.)

†Charging the Storage Battery.

A starting and lighting storage battery, could be charged by removing it from the car and taking it to a charging station, but owing to the great amount of current used, the size of the battery required, in order to last for a satisfactory period of time, would necessitate entirely too large a battery. **Therefore a dynamo, also termed a "generator,"** is operated from the engine. When the engine is running the car at a speed of ten miles or more per hour, this generator, generates electric current and stores it into the storage battery. The generator is treated in the next instruction.

---

*See "index" for explanation of "volts and amperes," also index for "storage batteries." Only "direct" current is used for starting motors. See "index" for "direct" current.

†The positive terminal of a storage battery is usually grounded, if system is a single wire. The negative could be grounded, as it would make no difference.

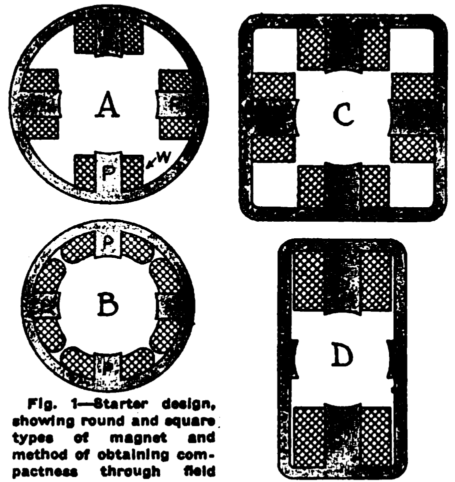


Fig. 1—Starter design, showing round and square types of magnet and method of obtaining compactness through field winding considerations and filling of magnet spaces

Field Magnets.

Or "pole pieces" are usually fitted with poles for the field windings (W) as shown in fig. 1. All starting motors have two or four poles (P) as shown.

The illustration on page 323 shows the principle of winding but are never constructed as illustrated on that page. A-B-C are "multi-polar" types with 4 poles and windings. D, is of the "bi-polar" type with two field windings. All starting motors are series wound.

When the multi-polar field is used the conductors on armature, revolving between them, cut the magnetic lines of force many more times in one revolution so that as the size of machine increases the speed decreases—which is an advantage.

Fly Wheel and Crank Shaft Drive.

Figs. 4 and 5 is a typical example of a starting motor (the Westinghouse). This motor is for fly wheel drive and could be equipped with the "Bendix inertia gear drive" page 326. Or with the Bijur below.

Fig. 6 shows double reduction gearing inside of motor housing, if starting motor is intended for crank shaft drive—which allows for slow speed connection, by chain or gears to crankshaft—see page 324, fig. 7.

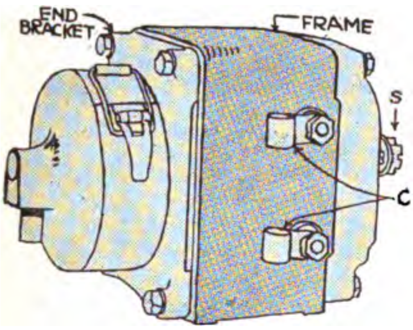


Fig. 4. For fly wheel drive.

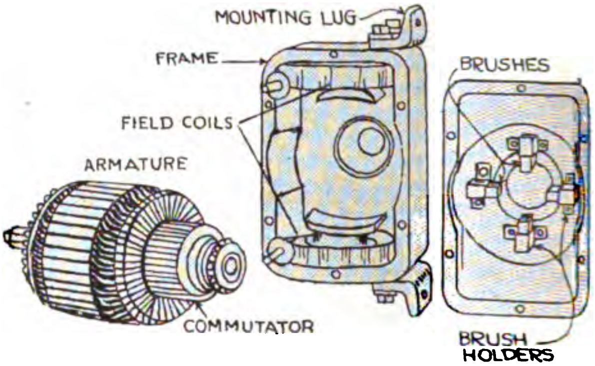


Fig. 5. For fly wheel drive.

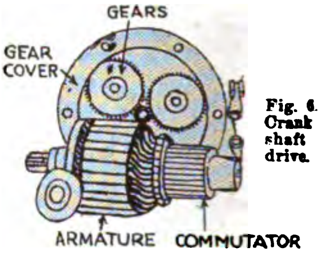


Fig. 6. Crank shaft drive.

The Bijur Double Gear Drive.

The Bijur double geared pinion shift (fig. 7) for starting motors driving through the fly wheel is similar in some respects to the Bendix (page 326) and can be attached to the armature shaft (A) of any starting motor with shaft machined to fit it.

Name of parts; A—armature shaft; B—drive shaft; D—driving gear; E—clutch; H—sleeve; L—clutch spring; M—pinion which meshes with fly wheel gear or pinion; O—light spring; X—pinion on end of armature shaft.

To start engine: Driving gear (D) rotates drive shaft (B) through clutch mechanism (E & F). This causes pinion (M) to screw itself to left along the shaft (P) and after meshing with teeth of fly wheel (M), continues to travel in mesh until (M) comes in contact with sleeve (H). It then pushes (H), the whole clutch assembly and driving gear (D) in same direction and compresses clutch spring (L).

When the members are in this position there is sufficient pressure between the face of the driving gear (D) and the clutch member (E) to cause the clutch to transmit to the driveshaft the power required for cranking. This it continues to do until the engine begins firing.

When the engine starts the pinion (M) is rotated faster by the flywheel than by the electric motor. It, therefore, screws itself to the right and out of mesh with the flywheel teeth. On **coming out of mesh** the pinion is cushioned by the spring (O).

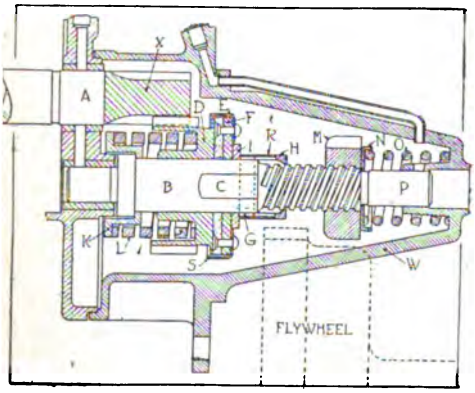


Fig. 7. Bijur double-geared pinion shift
See also page 925 for Bijur generators.

HART NO. 160A—Field Poles or Magnets of a Starting Motor. Example of a Starting Motor For Fly Wheel and Crank Shaft Drive. The Bijur Double Gear Drive. See page 373, address of Electric Motor Mnfg'rs.

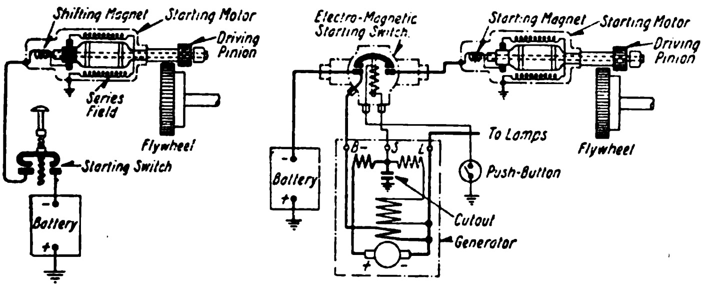


FIG. 3—WITH HAND OR FOOT OPERATED STARTING SWITCH

FIG. 4—WITH ELECTRO-MAGNETICALLY-OPERATED STARTING SWITCH CONTROLLED BY PUSH-BUTTON

DIAGRAM OF ELECTRICAL AND MECHANICAL CONNECTIONS OF MOTOR FOR AUTOMATIC ELECTRO-MAGNETIC PINION SHIFT.

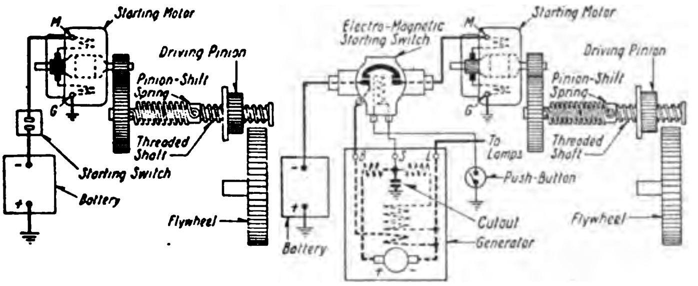


FIG. 10—WITH HAND OR FOOT-OPERATED STARTING SWITCH

FIG. 11—WITH ELECTRO-MAGNETICALLY-OPERATED STARTING SWITCH CONTROLLED BY PUSH-BUTTON

DIAGRAM OF ELECTRICAL AND MECHANICAL CONNECTIONS OF DOUBLE-REDUCTION MOTOR AND SWITCH FOR AUTOMATIC SCREW PINION SHIFT

(Single-Reduction Motor Has Screw-Shift Directly on Motor-Shaft Extension)

Starting Motor Switches.

Can be operated by "hand" or by "foot." If hand operated it may be in the form of a "single pole" switch or a "push button." If by foot it is usually by a foot pedal.

Starting motor drive systems are divided into three systems of drives; fly wheel, transmission and crank shaft drive.

Switch for crank shaft drive: a "geared starting motor" connected to the crank shaft is usually employed (see fig. 2, chart 159). The starting motor drives through an over-running clutch on the engine shaft. Pressure upon the starting pedal of switch closes circuit through the starting motor and battery. Releasing the starting pedal cuts off the current from the battery to motor. The switch that is used with this application has only a short travel as there are no gears to shift by the operation of the switch pedal.

Switches for fly wheel drive may be divided into three classifications as mentioned below.

Non-automatic mechanical shift, employs a switch lever that shifts the pinion (gear), also closes starting switch, first spinning the motor then shutting off the power till gears mesh with motor gear, turning from its momentum, finally throwing on full power and cranking the engine, see fig. 6, chart 160.

Automatic mechanical shift. Worm shaft mechanism to throw pinion into mesh automatically without shock when motor starts; throws pinion out when engine picks up, see fig. 10 and 11, also chart 160. Note that a hand or foot operated switch or an electro-magnetic switch with push button can be used (see below).

Bosch fly wheel starting motors (known also as the Rushmore system) operate on the electro-magnetic principle, but without extra gear shifting solenoid. "See chart 161."

Electromagnetic shift. A solenoid on one end of the motor throws a spirally cut pinion into mesh with gear on flywheel when the starting switch is closed and releases it when the engine picks up. Either foot switch or electrically operated switch with push button control can be used, see fig. 3 and 4. Note the type switches which can be used with this system.(Note in fig. 4—word over armature—reads: "starting magnet," should be "shifting magnet.")

The "electromagnetic" gear shift, is the Rushmore principle, chart 161, also see figs. 3 & 4 above.

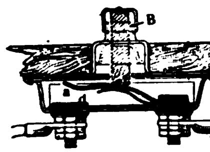


Fig 9

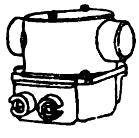


Fig. 7 — Electro-Magnetically Operated Starting Switch Automatic Pinion Shift.

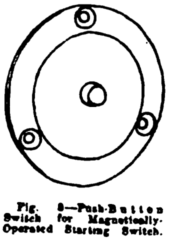


Fig. 8—Push-Button Switch for Magnetically-Operated Starting Switch.

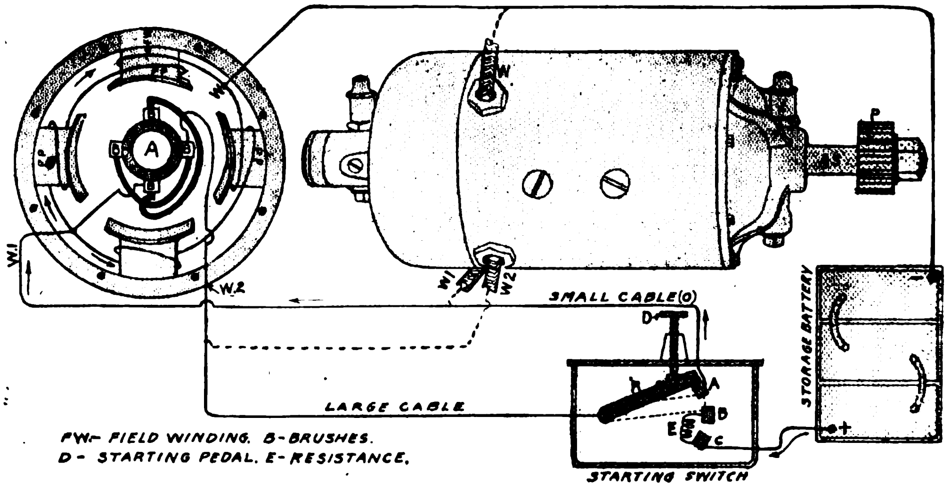
Types of Starting Switches.

Fig. 9. Shows a foot operated starting switch for automatic pinion shift" drive as "Bendix." Contact is closed at (a) and (d) when (B) is depressed.

Fig. 8 shows the "push-button" switch. **Fig. 7** the electro-magnetically-operated switch for the "electrically-operated automatic pinion shift" as shown in diagram of fig. 11 and chart 161, and also the automatic mechanically operated pinion or gear shifts see chart 160, fig. 8.

The principle of the electro magnetic type switch: The operation of this switch is controlled by a push-button, (see fig. 8) which closes an auxiliary circuit from the battery. This circuit energizes the electro-magnetically operated switch as per fig. 7 and as shown in diagram of fig. 4 and 11.

See chart 160 for switch of resistance type used with the "non-automatic" gear shift.



Construction of motor: Series wound type; and is intended for use in connection with a 6 or 12 volt storage battery.

The construction of the motor is such that the armature can be shifted endwise in its bearings, parallel to its axis. In the normal or non-operating position, the armature is held out of its electrical center or, in other words, out of line with the pole shoes, by means of a spiral spring in the commutator end of the armature shaft; therefore, when in the normal position, the pinion on the driving shaft of the starting motor is out of mesh with the gear ring on the flywheel of the engine.

The motor is regularly provided with three terminals (W, W1 and W2), two of which are heavier, or of larger diameter than the other. The two heavier terminals are for the main circuit, and the single small terminal is for the shunt circuit.

Principle of operation: During the first part of the downward movement of the switch pedal (D), an electrical circuit is established which causes the current from the battery to pass through the switch "shunt" (E).

The amount of current that can flow is limited by the resistance (E) of the circuit, but, of the current which passes through the switch "shunt," a small portion is allowed to flow through the motor armature, while the greater portion flews through the motor field coils, forming thereof a strong electromagnet.

The result is a powerful attraction between the field coils and the armature, causing the latter to be drawn endwise into the magnetic center of the motor or, in other words, into its working position between the pole shoes. The passing of the small current through the armature causes the armature to rotate **slowly,** and as the rotary motion occurs simultaneously with the shifting of the armature endwise, the meshing of the motor pinion (P) with the gear ring on the engine flywheel (FG) is accomplished quickly and positively.

As the switch pedal (D) reaches its limit of motion at (C), the flow of battery current through the switch "shunt," as well as that through the shunt cable to the field coils, is interrupted, and a straight series motor connection is established, allowing the entire current to pass through the motor field and armature windings, and causing the engine to turn over until it starts firing.

As soon as the engine starts, the starting motor is relieved of its load, and the current passing through it drops rapidly in volume, this being a characteristic of series motors. In consequence, the strength of the field magnets is lessened to a point where the spiral spring in the end of the armature shaft overcomes the magnetic attraction holding the armature, and returns it to the original or non-operating position; it is this action that automatically and positively throws the armature shaft pinion out of mesh with the flywheel gear-ring. Thereafter, until the starting switch is released, any current which continues to pass through the armature will merely cause the latter to revolve freely but without meshing with the flywheel, due to the fact that the amount of current utilized when the motor is running free is not sufficient to overcome the tension of the spiral spring.

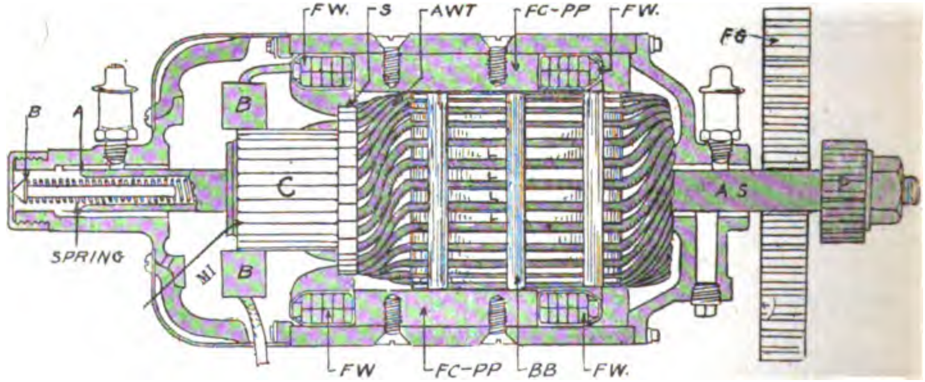


Fig. 4; C, commutator; B, brushes (carbon or copper); L, laminated iron core. A. W. T.—armature winding terminals. **B. B.,** brass bands around armature to hold coils in place. **F. C.,** field core, also pole pieces. **F. W.,** field winding. **A. S.,** armature shaft. **S,** segment of commutator, where armature coils connect. **MI.,** mica insulation between the copper commutator segments. **P,** drive gear or shaft pinion. **FG,** fly wheel driven gear.

HART NO. 161—The Rushmore Principle of Starting Engine through Fly Wheel, with "Displacement" Type of Armature. This system is now known as the **Bosch System.** It is als alled an **"Automatic Electro Magnetic Gear Shift" system.**

Bendix Starting Motor Inertia Gear Drive.

Starting motor (six volt): Carried on the flywheel case at the rear of the engine over the fly wheel extending slightly back into the driver's compartment of the car.

The starting switch is mounted directly on the starting motor, the button of which extends through the casing convenient to the driver's foot.

When starting button is pressed electrical connection is made with battery and current causes motor armature to rotate rapidly, this causes gear (A) to travel towards motor and mesh with gear ring (D) on fly wheel. (B) is a coarse threaded sleeve, which is connected to shaft through spring (C) this allows a certain amount of flexibility and prevents a too sudden application of the power.

In the type shown in fig. 8, page 326, the spring is positioned at inner end of sleeve, and gear (A) travels in opposite direction but the principle is exactly the same. Various constructions are necessary to fit different installations. In this construction counter-weight on gear (A) is in the form of a flange.

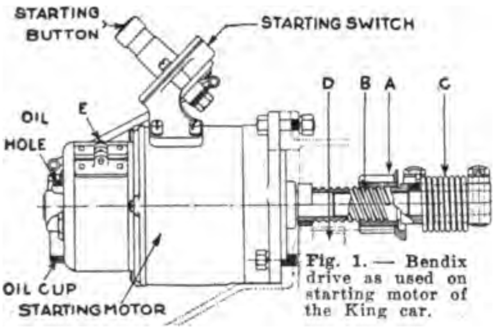


Fig. 1. — Bendix drive as used on starting motor of the King car.

As soon as the small gear (A) is fully engaged with fly wheel gear (D), it comes up against a stop and is locked firmly to sleeve (B), thus rotating with the starting motor armature shaft and allowing the starting motor to crank the engine.

When the engine starts under its own power and the starting button is released, the small inertia gear (A) is thrown out of mesh with the flywheel gear (D), and the starting motor comes to rest.

Care of Starting Motor.

Lubrication: The bearing at the commutator (rear) end is fitted with a wick oil cup underneath the bearing. The wick dips into the lubricant and the upper end rests against the armature shaft, so the oil is constantly fed to the bearing. The wick should be cleaned with gasoline and the oil cup filled with non-fluid oil or vaseline once every 3000 miles. Oil hole is on top of bearing bracket.

Commutator: The commutator and brushes can be exposed by unscrewing the screw in (E) and removing the band cover. Do not touch the commutator so long as the motor starts properly. If it becomes dirty, clean with a piece of canvas moistened with gasoline; if rough, polish with No. 00 sand paper while revolving. See page 407 for "Care of Starting Motor."

**Bendix Starting Motor Troubles.

In case the starting motor fails to start the engine when the starter button is pressed, the following will be found helpful in tracing the trouble. (1)—Ignition switch in "off" position. (2)—Throttle closed. (3)—Carburetor not choked. (4)—Loose ignition wire connections. (5)—Interrupter breaker points out of adjustment. (6)—No gasoline in main tank. (7)—No gasoline in gravity tank. Remove carburetor float chamber cover and if no gasoline, see that shut-off cock underneath gravity tank is open. If there is gasoline in the main tank and none in the gravity tank, see gasoline feed instructions for remedy, page 165.

Starting motor runs, but does not crank engine. This trouble is only apt to occur in extremely cold weather when the oil congeals, causing the starter inertia gear to stick, and not move into mesh with the flywheel gear. A slight tapping on the starting motor housing will usually overcome the difficulty, but if this fails, start the engine with the hand crank and when motor is warmed up, it will operate properly.

Starting motor does not run. This might be caused by any of the following: (1)—Loose connections at either starting switch, starting motor or battery. (2)—Battery discharged. (Test solution with hydrometer.) (3)—Dirty starting motor commutator. (4)—Worn or loose brushes. (see pages 407 and 422.)

If pinion goes into mesh with a "bang" and there is considerable noise while cranking, it is evident that the clamping bolts (R) fig. 2, have loosened. Be particular to line up the motor properly before drawing them up. By turning the threaded sleeve (B) with the fingers, the pinion (A) can be moved into mesh, and unless it meshes easily, it is not in line.

Starting switch—good contact and a quick release, is important. Examine spring occasionally, as it must be in good order to prevent damage to gear teeth. Keep clamping bolts (that hold down motor) drawn up snug at all times, otherwise motor will shift out of line.

Occasionally a Bendix drive gear will stick in mesh, and will not release after the engine has started. This is often caused by improper alignment of a starting motor. Or if the gear meshes harshly, or spins considerably without meshing, proceed as follows:

(1)—Remove the outer end bolt holding the Bendix spring and sleeve in position and remove the spring sleeve and gear.

(2)—Wind a strip of emery cloth on a round stick and thoroughly clean inside of threaded sleeve.

(3)—Clean the armature spindle carefully with a fine emery cloth, removing all dirt and rust.

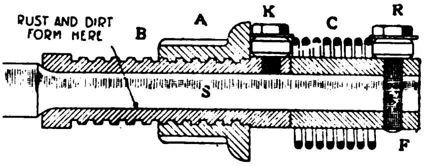


Fig. 2—Bendix drive troubles may develop from rust and dirt collecting on the inner drive shaft and sleeve. This should be cleaned out by means of emery paper, being careful no trace of emery is left.

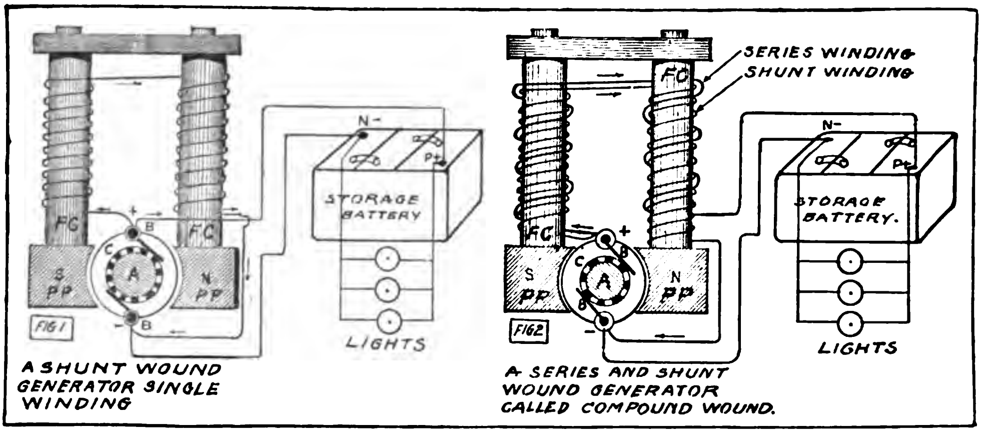
(4)—Apply a small amount of light graphite grease to the inside of the Bendix sleeve, and replace the parts.

(5)—To bring the starting motor into alignment, loosen the four bolts holding the starting motor to the transmission, and place a $\frac{1}{64}$ to $\frac{1}{32}$" shim between the motor support and gearbox bracket. This shim should be placed on the inside of the motor nearest the gearbox (this may or may not be necessary).

It is essential that no other parts of the Bendix drive as mentioned above under "lubrication," with exception of the inner sleeve, be lubricated. The action of the starter depends upon the inertia weight attached to the gear, and this action is hindered if there is any collection of oil, grease or dust upon the threads carrying the gear.

CHART NO. 161A—Example of a Modern Starting System — the Electric Starting Moto with a Bendix Inertia Gear Drive (used on the King Car). The Bendix drive is used o different makes of starting motors and is the most popular system in use (fig. 8, page

See page 360. for King wiring diagram. **See also page 668.



FC—field core. PP—pole pieces. A—armature. B—brushes.
A Simple form of Generator with a "shunt" and another with a "compound" winding.

Note the generator supplies current to charge the storage battery; also for lights. If the generator stops or slows down, then the current would flow back into generator from storage battery, therefore a "cut-out" is required, as will be explained further on.

The above generator has the "electro-magnetic" type of field magnets.

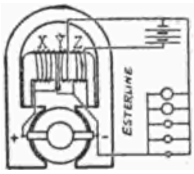


Fig. 3.—Esterline Generator has permanent magnets and auxiliary "electro magnets" and may be arranged in the Compound Class. The permanent magnets serve the same purpose as the shunt field. At low speeds the field windings assist the permanent magnets and at high speed they oppose them, so the output is maintained fairly constant. On the Esterline an auxiliary winding (Z) is used to increase the output when lamps are turned on.

Armature is "drum" type, if it was the shuttle type as usually used on magnetos, it would generate an "alternating" current. Therefore would not charge the battery.

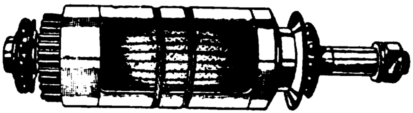

SHUTTLE TYPE ARMATURE WITH ONE WINDING - LOW TENSION

Fig. 7.—Shuttle type of Armature, used on magnetos, for ignition; not suitable for **storage** battery charging—**generates "alternating" current.** (Also see Chart 120.)

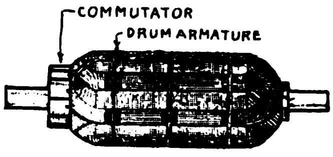
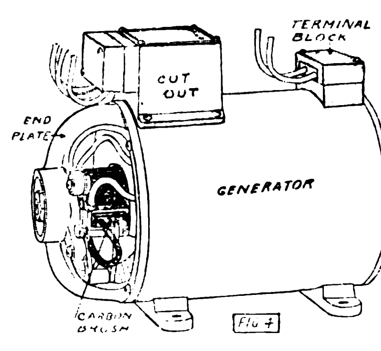
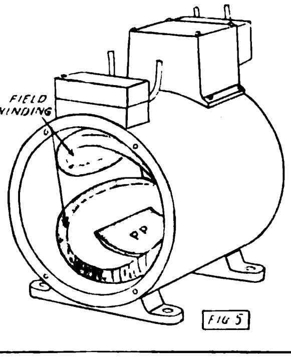
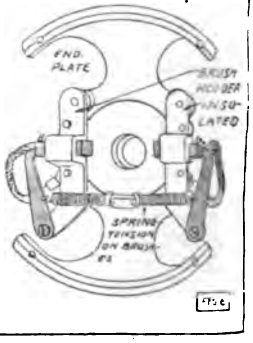


Fig. 8.—Drum type of Armature—type used on generators for charging batteries **and lights.** Generates "direct" current.







A modern type of generator, showing the cut-out location on generator—this cut-out is sometimes placed on inside of dash.

Showing the two pole pieces (PP), "bi-polar" **type; also** winding on fields.

Showing end plate which supports brushes, and bearing end of armature shaft.

CHART NO. 162—Principle of the Electric Generator.
1 is the commutator.

INSTRUCTION No. 27.

THE ELECTRIC GENERATOR: Principle, Construction, Operation and Drive. The Magnetic Cut-Out. Series, Shunt and Compound Windings. Regulating Methods; Bucking Series, Mechanical Governors, Third Brush, Voltage or Potential and Thermal. Ignition from Direct Current Generator.

Relation of a Generator to an Electric Motor.

****The electric generator** is similar in many respects to an electric motor. The principal difference being in the winding. The motor is usually "series" wound and the copper wire is heavy or coarse, in fact it is in the form of copper strips on some motors. With a few minor changes the electric generator can be run as a motor, using the same winding.

The series motor possesses great starting power, but under a light load may attain a dangerously high speed. **A series dynamo,** to be used as a motor, and run in the same direction as it does as a dynamo, must have the leads from the brushes interchanged.

A **"series" wound generator** will rotate in an opposite direction to that as when run as a motor.

A **"shunt" wound generator** when used as a motor, will turn in same direction as when used as a generator.

The shunt wound motor has not such great starting power as a series wound machine, but runs much more uniformly in speed under a varying load. Brush leads remain as in dynamo for the same direction of rotation.

A **"compound wound" generator,** when used as a motor will turn in an opposite direction—providing that if the "series" part is more powerful than the "shunt" and in the same direction if the "shunt" is more powerful than the "series"—this is called a differential winding and will be explained later in the Entz and other systems where the same machine is used for a motor or generator.

The compound wound motor is about equal to the shunt motor in starting power, and runs at an almost constant speed under all loads. Brush leads for motor remain as in dynamo. To reverse direction of rotation of motor, current must be reversed through armature.

The generator, however is usually separate and distinct from the starting motor. The Delco however, (in some of their systems) employ one armature with two commutators; one operating when used as a generator and the other when used as a motor. The Entz system is another example of one armature with two windings, used for both a generator and starting motor, see page 352.

**Principle of the Generator.

***Dynamo machines.** This machine is based on a discovery of Faraday, who found that when a conductor is moved across a magnetic field, a momentary current of electricity is generated in it by what is called **induction.**

The dynamo consist of two main parts—(1), a means of producing a strong magnetic field known as the "field magnets"; (2), a series of conductors in which the currents are generated by induction, called the "armature."

One of these parts must be capable of rotation relative to the other. If one conductor on such an armature be connected to a galvanometer it will be noticed that during half a revolution, either of the armature or field magnet, the current is in one direction through the conductor and that for the other half of the revolution the current is in the opposite direction.

Such a current is called an "alternating" current, and the machine producing it is called an alternating-current generator, or a "magneto."

If such a machine is fitted with a number of metallic segments insulated from each other, called a "commutator," to which equidistant conductors of the armature are joined and two brushes are placed on opposite segments (for a two-pole machine) of this arrangement so that the armature of the machine can be rotated while the brushes remain fixed and make contact with the segments as they rotate, and so arrange the brushes that just as the current is reversed in a conductor the segment attached to that conductor is under the brush, the current produced will be continuous in direction. A machine so arranged is termed **a continuous or "direct" current dynamo.**

A dynamo is perfectly reversible. If electrical energy is supplied, it is transformed into mechanical energy and when thus used is spoken of as a motor.

---

*A dynamo and generator are referred to as the same. **Those desiring to go deeper into the principle of the dynamo and motor—we recommend "Lessons in Practical Electricity"—see ad back of this book.

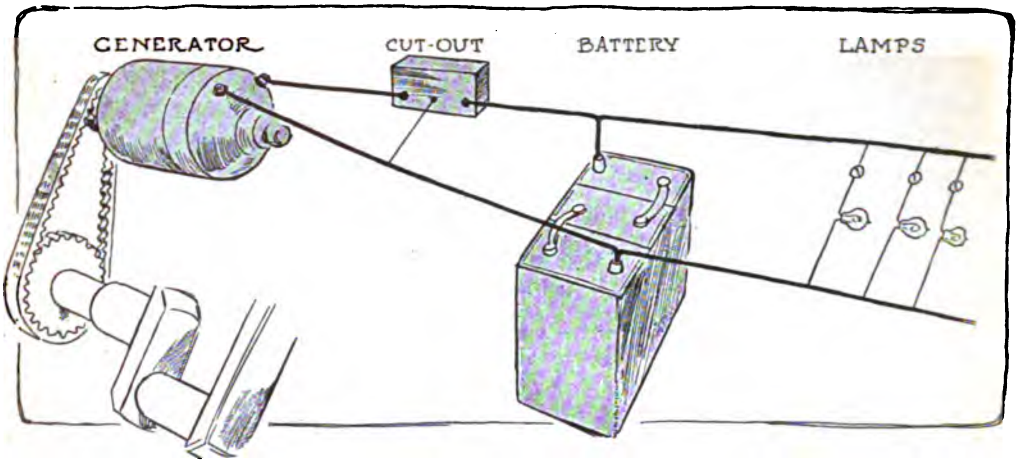


Fig. 1. The generator is usually driven from crank shaft of engine as shown in chart 164. It charges the storage battery and supplies current for lights.

The storage battery merely "floats on the line." The cut-out action is shown in fig. 2. **The storage battery supplies current for starting, ignition to start on, and the lights, when generator is not running fast enough. This would be termed a "constant"** source of electric supply, which, is very important when first starting, as the ignition does not depend upon a "mechanical" method of generating the ignition current to start with, or for lights when engine is idle.

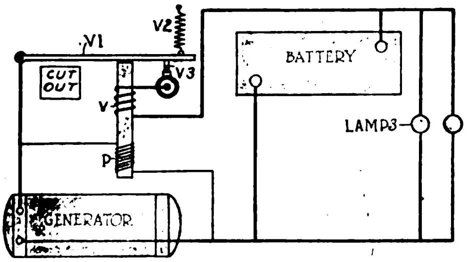
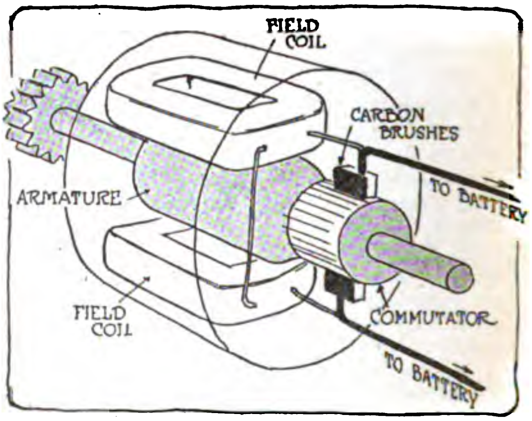
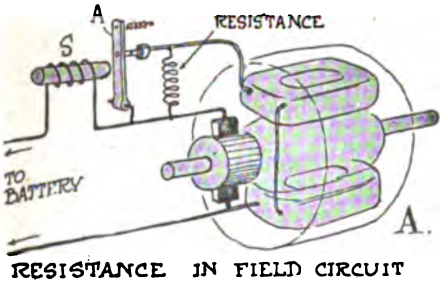
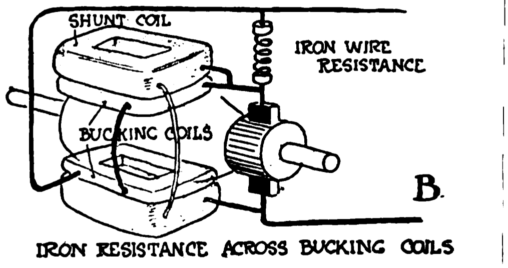


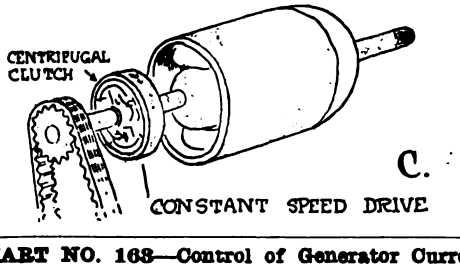
Fig. 2. The automatic magnetic cut out, opens the circuit between battery and generator when the generator is running slow or engine is stopped, also referred to as the **"vibrator type"** of cut out. The principle is explained on page 344.



A shunt wound generator—showing how current is taken from brushes to energized field magnets. A plain shunt wound generator usually requires a magnetic type of current regulator as in (A).







A compound wound generator, (fig. 2, chart 162). in many cases requires no outside mechanism for regulating the output.

A—"magnetic" principle of regulating the current and keeping it constant, at high speeds: **resistance is thrown in to the field circuit (see chart 168).**

B—Bushmore "thermal" principle of **placing iron** resistance across bucking coils.

C—A centrifugal governor clutch releases over certain speeds, thus keeping the speed **constant—"mechanical** governor principle."

CHART NO. 168—Control of Generator Current. Some of the methods for regulating the voltage and amperage output of the generator. **(Motor Age.)**

Parts of the Direct Current Generator (Dynamo.)

The parts of the generator are: (1) The armature; in which the current is generated. (2) The field cores or magnets; "permanent" or "electro." (3) The pole pieces; bi-polar or multi-polar. (4) Commutator. (5) Brushes; metallic or carbon. (6) Regulation of current output.

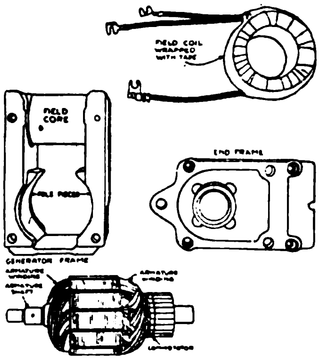


Fig. 1. Parts of a direct current generator with one field winding above armature.

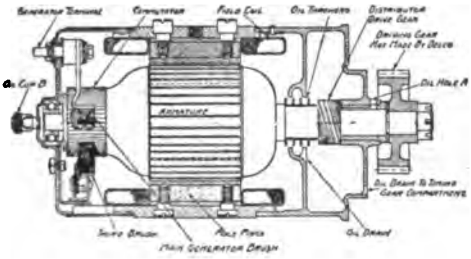


Fig. 2 Parts of a direct current generator with two field windings, one on each side of armature.

The Generator Windings.

The windings on the field-cores of a generator; instead of a plain "series" winding as on a starting motor, there is a "**shunt**" or "compound" winding, see figs. 1 and 2, chart 162. Note the terminals of the field winding are connected to the brushes, instead of one end of field winding going to the battery as in fig. 1, chart 158.

The word "shunt" means an additional path established for the passage of an electric current or discharge. Another winding, is the "compound winding," see **fig. 2**, chart 162.

Continuous or "direct" current dynamos are divided into three classes, differing in the manner in which the field magnets are wound.

1. **Series machine.** Coils on field magnets consist of a few turns of large wire, through which all the currents generated flow; joined in series with armature and external circuit.

2. **Shunt machine.** Coils on field magnets consist of many turns of small wire arranged as a shunt to external circuit, and allowing only a small fraction of the total current generated to flow through them.

3. **Compound machine.** Partly excited by shunt and partly by series coils.

The field core is that part of generator on which the wire winding is wound. When wound with insulated wire and a current of electricity passes through them, they are called "**electro magnets,**" **meaning** that they are magnetized when running; at which time current flows through the wire winding and magnetizes the core thereby producing the magnetic field in which the armature revolves.

A generator which generates a "direct" flow of current can have either a "permanent" magnetized field magnet, as in fig. 2, page 323, or "electro" magnetized fields, where the fields are magnetized only when armature is revolving—but in every instance the armature must be "drum" wound type and not the "shuttle" type. The "electro field magnets" are more popular.

Sometimes "permanent" magnets are used for the field magnets, for instance fig. 3, chart 162, on a "direct" current generator, and the appearance being similar to a magneto, the impression is formed that it must produce an alternating current. By referring to page 256, the subject of "alternating" current magneto type of generator is explained.

Armature.

The type of generator used for charging storage batteries and also for ignition when used in connection with a storage battery and lighting system generates a "**direct**" flow of current.

A generator which generates a "direct" flow of current must have a "**drum**" type of armature. If armature was of the "shuttle" type, as per fig. 4, page 256, it would make but two waves of current at each revolution; the waves being strongest just as the end of armature breaks from the pole piece, and not being provided with a commutator, to change the direction of the induced current, this armature would generate **alternating** current; because alternating current does not flow in one direction continuously is the reason why it is not suitable for charging a storage battery. To charge a storage battery the current must flow in one direction continuously.

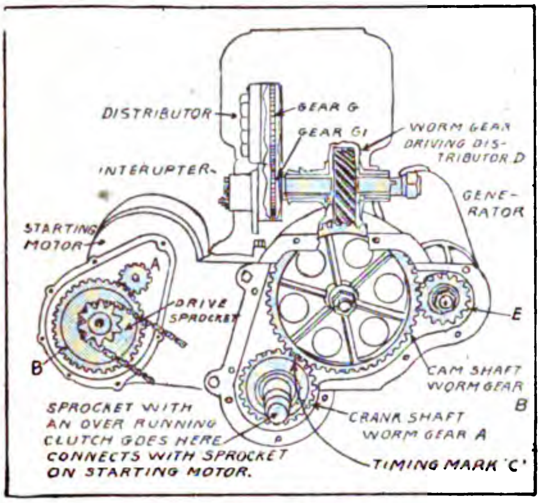


Fig. 1. Driving the generator from **cam shaft, also distributor and "interrupter,"** but independent from each other. The **starting motor drives** "through the crank shaft" by a silent chain and over running clutch. This system is a **"three unit" system** formerly employed by **"Studebaker Six."** See page 244, fig. 4, for description of this "interrupter" timer.

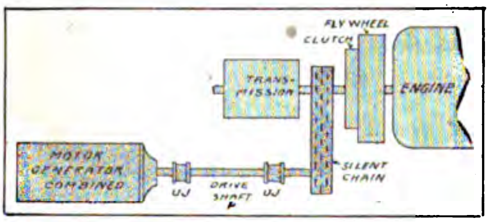


Fig. 3. The generator and starting motor are combined in one. Drive is through transmission shaft by means of a silent chain. The ignition is independent. This is a "two unit system." This system formerly used on Chalmers, see chart 171.

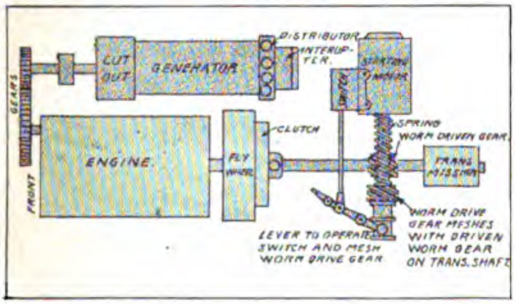


Fig. 4. Generator driven by gear from crank shaft. The starting motor drives through the transmission shaft. **Ignition is** the "interrupter" type mounted on the generator but driven independent of the armature shaft, otherwise, on account of the clutch on other end of armature shaft the timing would be thrown out of time. **Reo system.**

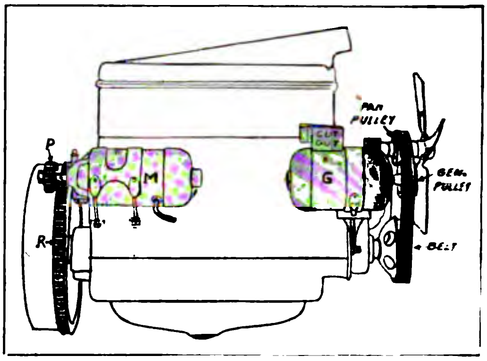


Fig. 5. Generator driven by belt which drives the fan. Starting motor is the "automatic electro magnetic pinion shaft" drives through fly wheel. This system would be termed a "three unit system."

The ignition is the Atwater-Kent system and is driven from cam shaft separate. This system formerly used on Regal.

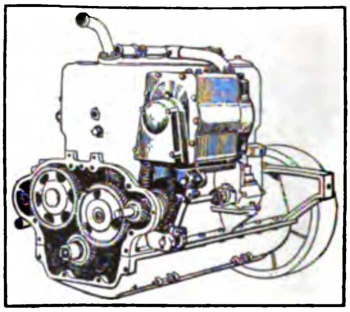


Fig. 6. Generator, driven by gears and silent chain.

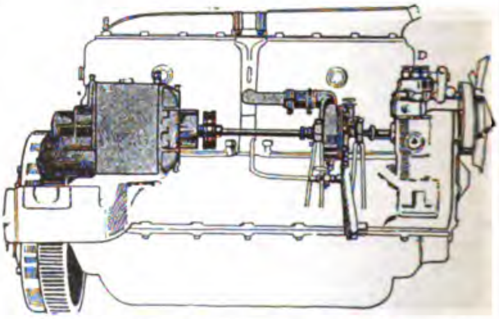


Fig. 7. Generator and motor combined. One armature serves for both. **Generator driven from pump shaft also distributor and timer. Starting** motor drives through the **fly wheel. Delco** system used on **Hudson, Cadillac, Olds,** Buick, and others.

CHART NO. 164—Various Methods for Driving Generators. "See Specifications of Leading Cars," giving makes of systems used on various cars.

Charging Storage Battery—from Generator—how Connected and Disconnected from Generator.

The electric generator is operated by belt, chain, shaft, or gear drive from the engine, and supplies electric current to the storage battery and the lights.

When the engine is not running, or is running at a very low speed, the lights and ignition are supplied entirely by the battery. This provides a "**constant**" source of supply of current for ignition.

Automatic cut-out: The Ward Leonard as an example, see pages 342, 344. A magnetic switch, **called an automatic "cut-out"** is placed in the circuit between the generator and storage battery. This device automatically connects the generator to the lighting system and battery when the engine is running at—say, approximately 7 to 10 miles per hour car speed or over, and charges the battery and supplies current for light and ignition.

When running at less speed, the "cut-out" disconnects the generator from the battery and lighting circuit, and the battery then supplies the current.

If lights are burning when generator is connected to battery, then the generator furnishes part of the current to them; as the speed increases, the proportion of current supplied by the generator increases, until at high speed the generator supplies all of the current to the lights, and in addition, charges the battery. **The amount of current the generator furnishes to the battery,** depends upon the number of lamps burning, and the speed of the engine.

Therefore the purpose of the automatic "cut-out" is to **open** the circuit (as at V3, chart 165), when the generator is running slow or not running at all, so that current will not flow back into generator. **Also,** to **close** the circuit when generator is running fast enough, so that the generator **will** charge battery and supply current to the lights.

Floating a Storage Battery on the Line.

This term refers to the storage battery used in connection with a generator, where the storage battery supplies current. for lights, when generator is running slow or not running at all, as explained.

The generator charges battery and supplies current for lights, when running at sufficient speed. If the speed of engine is varied, part of time the battery would be in use and part of the time the generator—the battery would then be "floating"—see chart 163. The "**cut-out**" would be changing from one to the other—owing to the variable speed of engine.

***Regulation of Out-put of Generator.**

In a dynamo, the voltage increases with speed. The dynamo begins to charge the battery, at about 7 to 10 miles per hour, but it is also desirable to charge battery and supply current for lights at a higher speed.

As the voltage increases with speed, then the lights would be burned out and generator would be injured by excessive sparking at commutator, and an excessive amount of current would flow to the battery.

Therefore some form of "regulation" must be used to keep the voltage or potential and amperage or quantity of current constant at high speeds.

****Methods of Regulation.**

Regulators are classed as, "current" (amperage) regulators and "voltage" regulators, and operate in various ways.

(1) **By methods of winding the field coils** as shown in figs. 1 and 2, chart 162; compound and shunt connected, which controls the current (amperage) production at high armature speeds, and holds the current to the proper output.

(2) **By electrical magnetic devices** as shown in charts 165 and 168; which forces the current to travel through a resistance, thereby weakening the strength of the magnetic field, and consequently the output of the dynamo. These regulators can be wound to control the voltage or the current.

(3) **By a mechanical governor** which controls the speed of the armature to a fixed number of revolutions (see chart 170 fig. 3).

(4) **Thermally,** by an increase of resistance coming into play in connection with the shunt field winding by means of a rise in temperature, **due to increased current flow**—as explained in Rushmore generator system (chart 166, figs. 1, 2 and 3).

All regulation methods will be explained, under the description of different electric systems. For instance under "Delco" the "**variable resistance**" "**reverse series**" and "**third brush**" regulation will be treated, which are also explained on pages 345 and 925.

There are two principles of compound windings in general use: "differential compound" per page 343 and "cumulative compound" per page 347.

***It may be well to mention that voltage means pressure, and amperage means quantity.** The generator may be reading 5 amperes of current to the battery at a pressure of 6½ volts, but while the 6½ volts would go to each light, the 5 amperes would not go to one light, alone, as the lights cannot take but from 1 to 5 amperes each, according to their size. In other words no matter what quantity of current goes to the battery, the resistancec of the lamp filament allows only so much current to pass through it—yet if a higher voltage goes to the battery, then the lights would be burned out. For as the voltage increases above the voltage the lamps are intended to use, the lights get brighter until filament burns out. **See also page 343 and 345.

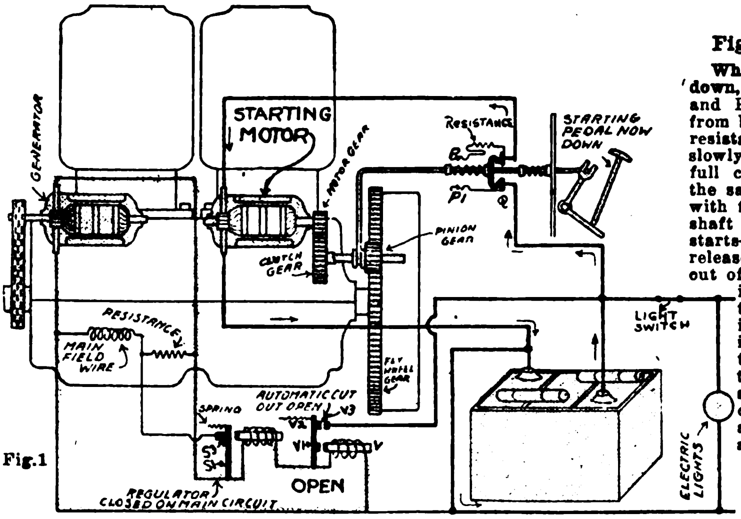


Fig.1

Fig. 1: Starting Engine.

When starting pedal is pressed down, switch makes contact at (P and P1), causing current to flow from battery to (P), thence through resistance, causing motor to turn slowly. Further depression of pedal full contact is made at (Q). At the same time pinion gear engages with fly wheel gear. Engine crank shaft then revolves and engine starts— at which time the pedal is released and pinion gear is thrown out of mesh and switch opened, or in other words, starting motor is then out of service, as it has done its work in starting engine. The storage battery supplies current for ignition and lights until a higher speed is reached. Note the circuit is open between storage battery and generator at (V3).

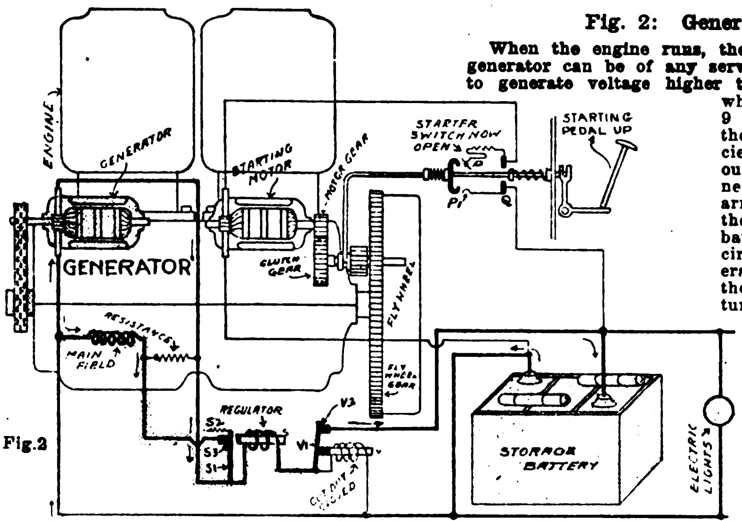


Fig.2

Fig. 2: Generating Current.

When the engine runs, the generator runs, but before generator can be of any service it must run fast enough to generate voltage higher than the battery. Therefore when engine is running about 9 or 10 m. p. h. car speed, the generator generates sufficient voltage to cause "cut-out" core (V) to become magnetized enough to draw cut-out arm (V1) to it—at which time the circuit is closed between battery and generator. Follow circuit from top brush of generator through regulator coil, thence (V3) to battery. Returning from battery to lower brush. The "main field" winding is merely "shunted" across the wires from brushes. Generator now supplies current for ignition and lights and battery is "floating on the line." see fig. 1, page 334.

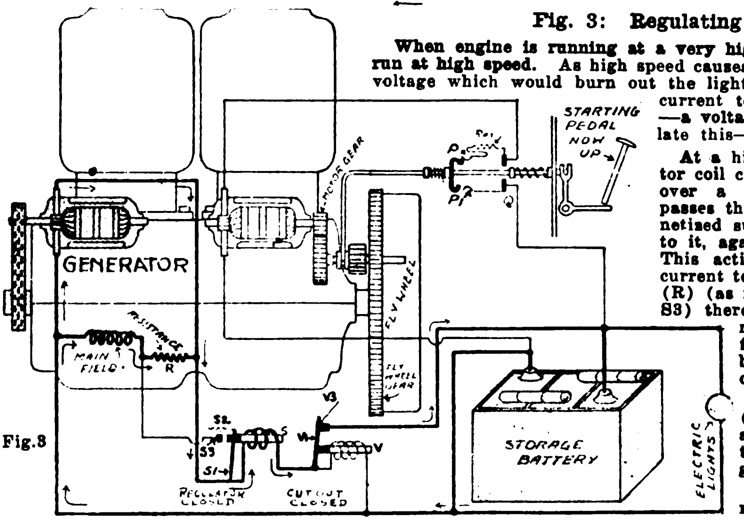


Fig.3

Fig. 3: Regulating Current.*

When engine is running at a very high speed, generator will also run at high speed. As high speed causes generator to produce a high voltage which would burn out the lights and increase the charging current to battery more than desired **—a voltage regulator is used to regulate this—note resistance (R).**

At a high rate of speed the regulator coil core (S), is wound, so that if over a certain amount of current passes through same, it becomes magnetised sufficiently to draw arm (S1) to it, against tension of spring (S2). This action forces the "main field" current to travel through the resistance (R) (as its circuit has been opened at S3) thereby weakening the field magnetism. When weakened sufficiently, the arm is drawn back again to (S3) by tension of spring (S2).

In actual practice this arm (S1) vibrates in running back and forth constantly, owing to variations of speed of engine.

Referring to fig. 2 again, note this resistance is not in action, because the field current flows through the path which has least resistance. But in fig. 3, it must flow through the resistance (R), because of the opening at (S3).

CHART NO. 165—A Simplified Example of Starting Motor and Generator at Starting and Various Speeds, showing Operation of "Cut-Out" and "Regulator," also Switch with Resistance.

See also page 344, explaining how and why the cut-out is demagnetized on reversal of current flow, which is not explained in this chart. See also page 342.

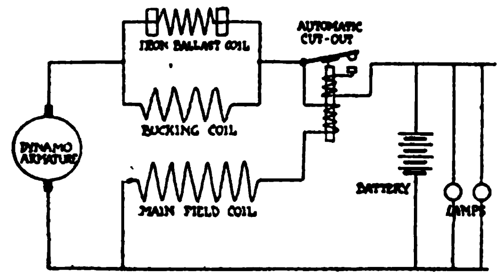


Fig. 1.—Diagram of Rushmore generating system. The bucking coil is a "series" winding on the field. The main field winding is "shunted" across. Cut-out is the usual magnetic type.

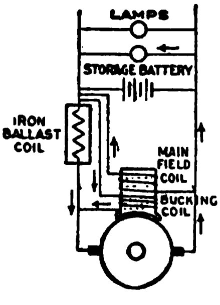


Fig. 2. — Diagram showing the main field winding and bucking coil series winding and location of "ballast coil" in circuit.

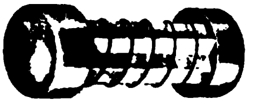


Fig. 3.—The "Iron wire" "thermal" type regulator of current, called "ballast coil" which allows a certain quantity of current to pass, but beyond that quantity the iron wire heats and offers resistance to flow of current in field, therefore the current must go through the bucking coil or series winding (in figs. 1 & 2) which action does not permit the current to increase but keeps it at a constant strength.

Rushmore Thermal Principle of Current Control.

The action is to reduce the strength of the field magnet at high speeds, by means of counter excitation produced by a few turns of magnet wire, called a 'bucking'' coil, on the field poles (fig. 2).

The amount of current passing through this bucking coil is determined automatically by the varying resistance of a small coil of iron wire, called the "ballast" coil, (fig. 3) which is made in the form of a cartridge fuse and carried in clips on the switch-block in the main line between the dynamo and the battery.

At low dynamo speeds and outputs of current this ballast coil is cold and acts as a short circuit to divert the current from the field bucking coil.

As the output increases the iron wire becomes heated, although its resistance remains practically the same as when cold, **until reaching a certain "critical" temperature, just below the dull red heat, its resistance goes up with a jump so that, practically speaking, it will not permit another ampere to pass** and after that any excess current must pass through the field bucking coil.

At car speeds below 15 miles an hour the dynamo acts as a simple uncontrolled shunt wound machine, while at the higher speeds, owing to the counter effect of the bucking coil, the resultant excitation is barely 1/6 of the excitation due to the main shunt field coil alone.

In order to keep the current in the main shunt field coil as nearly constant as possible, it is connected at a point beyond the ballast coil (fig. 2) instead of directly across the brushes. Thus it does not feel the fluctuation of voltage at the brushes.

The effect of controlling the bucking coil by the current output is to produce an approximately constant current at the higher speeds.

The voltage is determined by the storage battery and is simply the voltage required to force the specified current against the counter electromotive force plus the small internal resistance of the battery.

Assuming that the battery is in good condition the dynamo voltage will be slightly in excess of the open-circuit voltage of the battery, i. e., from about 6¼ to 6½ volts, depending upon the state of charge.

The battery is absolutely necessary to control the voltage of any automobile lighting dynamo and must never be disconnected therefrom while the dynamo is in use.

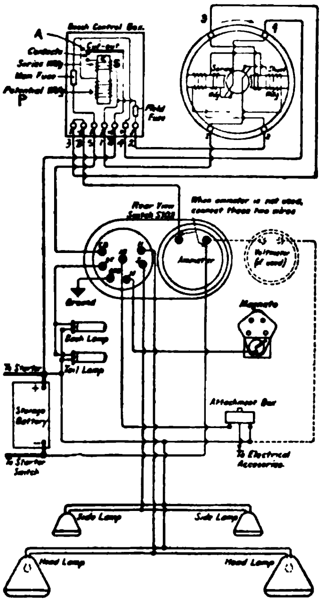


Fig. 4.—Diagram of the Bosch standard lighting system, using type D. S. G. dynamo, with an inherent method of regulation instead of a thermal principle.

Principle of Inherent Control.

The potential winding (P), fig. 4, remains always electrically connected with the dynamo and the current passing through this winding flows always in the one direction.

When the dynamo speed is such that the voltage generated is sufficient to send through the potential winding enough current to magnetize the iron core (C) to a point where it attracts the arm (A), it will cause the cut-out contacts to close. The instant the contacts are closed, current flows from the dynamo through the cut-out series winding (S) to the battery. It will be noted that under such conditions, the current passing through the cut-out series winding is in the same direction as that through the potential winding, thus adding to the magnetization of the iron core and causing the contacts to be held together so firmly that vibration or jarring cannot affect them.

When the dynamo speed drops below the minimum necessary to charge the battery, or, in other words, when the dynamo voltage is less than that of the battery, the current in place of flowing from the dynamo to the battery, **flows from the battery to the dynamo.** Under such conditions, **the direction of the current through the potential winding remains the same as in the case where the dynamo voltage exceeds that of the battery, the change being in the direction of current through the series winding of the cut-out, as shown by the heavy arrows.**

This reversal of current through the series winding creates a magnetic field which is in opposition to that created by the current in the potential winding (P), with the result that there is a neutralization of the magnetic attraction between the core and the iron button of the cut-out, with the further result that the spring causes the contacts to separate and disconnect the battery from the dynamo, **thereby eliminating any possibility of the battery discharging through the dynamo.** (For further information relative to Bosch system, see page 253.)

CHART NO. 166—Rushmore (now known as Bosch). Thermal Principle and Bosch Inherent Principle of Regulating the Current Output.

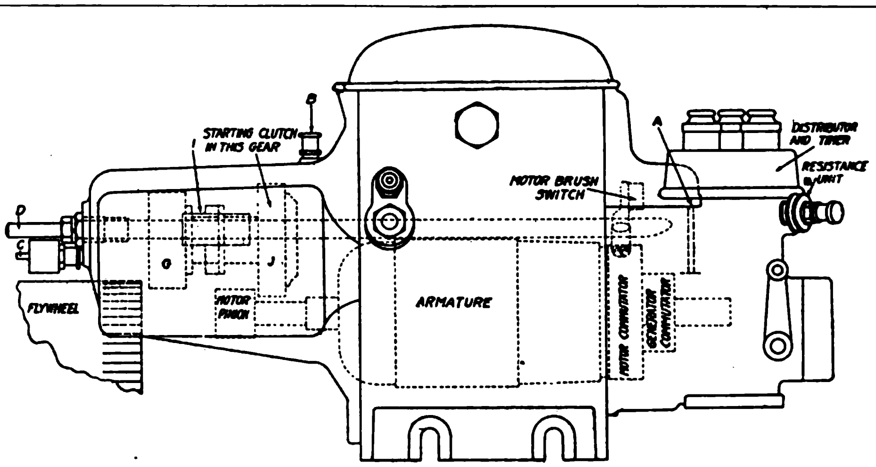


Fig. 1.—A single unit system (one type of the Delco system, as an example. Combines a **starting** otor, **generator** (direct current), and **ignition** all in one machine.

The one armature and one set of field magnets serve for both the motor and generator. There re two separate windings and two commutators, however. Ignition timer and distributor are mounted ith this unit, but the distributor drive spiral gear is not attached to the armature shaft as would aturally be inferred but is connected to the pump shaft, or shaft driving the generator. In other ords if connected to the armature shaft the action of the clutch used in connection with the genera- or drive (not shown above) would affect the timing operation.

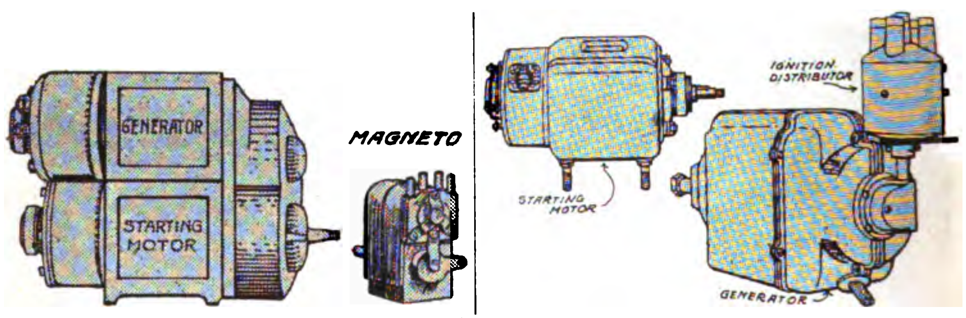


Fig. 2.—The two unit system, divided into classes; A and B.

A—Where starting motor and generator are ombined in one unit and the magneto (or coil nd distributor) for ignition in another, it is called "**two unit**" **system.** The above illustration is upposed to iillustrate a "**double decker,**" meaning, generator is placed over motor, using a separate armature and separate field magnets, see page 352.

B—Starting motor in one unit—generator and ignition in another. This is also a "**two unit**" **system.**

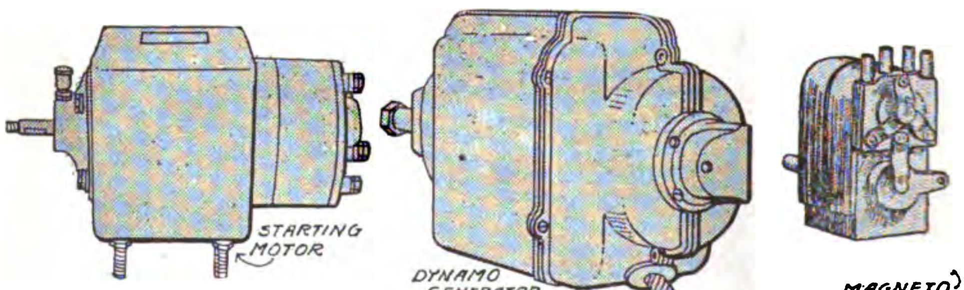


Fig. 3.—The three unit system—These are separate parts. The ignition can be of the "**magneto**" lternating current type, or of "coil and distributor" direct current type, in fact any ignition system eparate from the generator and motor, can be used.

RT NO. 167—Different Methods Employed to Combine and also Separate the Starting Motor, Generator and Ignition.

NOTE—There are many other types of motor-generators, but we will not show all of them in this treatise will confine our instruction to the general principle. After the principle is mastered, then the reader ought able to understand all systems.

Driving the Generator.

The generator must run when the engine runs, because it is necessary to recharge the battery and supply current for lights; and in many instances, ignition also. Ignition current, however, for starting, is provided by the battery.

The generator is usually driven from crank shaft or cam shaft, by means of chains or gear, or driven from the pump shaft. In some instances, it is driven from the drive shaft of the transmission. (See chart 164, fig. 3).

Over running generator clutch; when the starting motor and generator are **combined,** for instance see fig. 7, chart 164, note the starting motor drives through the fly wheel and generator is driven through the pump shaft. A "clutch" must be provided between this pump shaft and armature shaft, else the starting motor could not be independent.

The overrunning clutch enables the motor to turn the engine over when the power comes from the motor, but permits the engine to run forward without turning it. Therefore when power is cut off the motor, the engine can continue to run on its own power but the motor comes to rest . **(The roller type clutch** is the type in general use, see figs. 5 and 6, page 351, for the principle).

Ignition from the "Direct" Current Generator.

The modern ignition system is explained in instruction 19. Note the distributor and "timer" or distributor with "breaker" or "interrupter" are the approved methods.

Distributor drive method. The ignition distributor is quite often an integral part of the generator but is driven independent of the armature shaft if an "over-running clutch" is used between generator drive and generator, as explained above under generator clutch. If however, the starting motor and generator are **not** combined and the clutch is not used, then the distributor and timer can be driven from armature shaft, providing armature and ignition shaft are driven at proper speed.

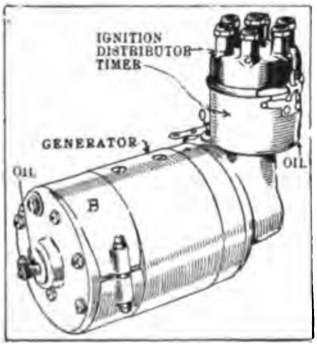


Fig. 1. The modern method of driving the generator and ignition unit, is to mount the ignition unit on the generator. The latter is driven by a silent chain at 1½ times engine speed and ignition shaft is geared to armature shaft and turns at ½ engine speed.

It is evident that if the distributor and timer were driven from armature shaft and a clutch was between the drive shaft of generator and the ignition system, the latter system would be thrown out of time. This would appear to be the case as in fig. 1, chart 167, where the starting motor, generator, and ignition unit are combined—but note, the ignition shaft, is independent of the armature shaft—see page 377 "distributor and timer shaft, how driven" and "generator clutch" page 386.

A modern method is shown in fig. 1 below and fig. 2, page 340. The starting motor in this instance, is separate, therefore this would be called a "two unit" system.

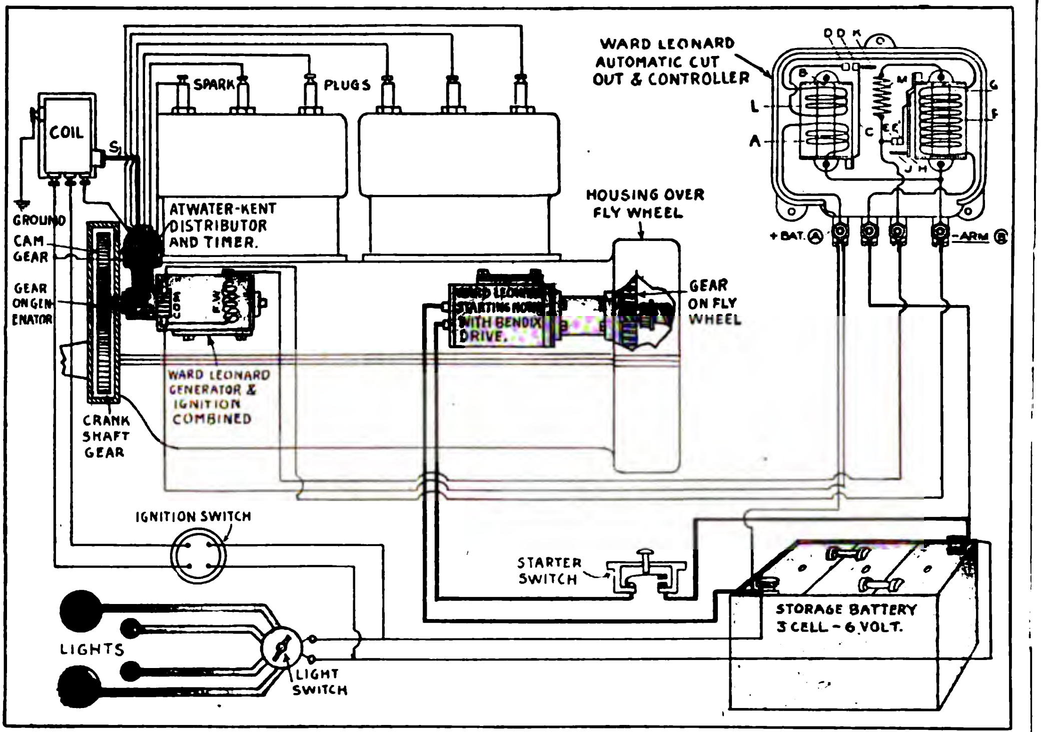
"Magneto ignition" term is often applied to the coil and battery system, and is no doubt confusing, as it implies that the current from the coil and battery system was "alternating," whereas it is a "direct" flow of current taken from the direct current generator when engine is running, or from the storage battery when starting or engine is running slow. This "direct" current passes through the primary winding of the high tension coil and is "interrupted" or contact "made or opened" suddenly by the timer or interrupter as explained in figs. 2 and 3, page 242.

This is why the term "magneto" ignition is sometimes referred to in connection with a generator of the "direct" current type; because the timer is of the "interrupter" type which gives a "single" spark, and not of the "commutator" type as explained in fig. 1, page 242, which gives a "succession" of sparks—see page 248.

The high tension coil used with the modern direct current generator system, is a double wound coil **without vibrator** as explained in fig. 4, page 245.

This coil is sometimes mounted on the generator, or, it can be mounted on dash, under hood or any convenient place.

A "constant" source of electric supply is provided with the coil and battery system. In other words, the battery is kept charged by the generator, hence it is always available as a constant source of electric supply for ignition and lights.


WARD LEONARD AUTOMATIC CUT OUT & CONTROLLER
DD K
B
M
G
F
L
A
C
EE
J H
+BAT.
-ARM
SPARK
PLUGS
COIL
S
GROUND
CAM GEAR
GEAR ON GENERATOR
ATWATER-KENT DISTRIBUTOR AND TIMER.
WARD LEONARD GENERATOR & IGNITION COMBINED
CRANK SHAFT GEAR
HOUSING OVER FLY WHEEL
WARD LEONARD STARTING MOTOR WITH BENDIX DRIVE.
GEAR ON FLY WHEEL
IGNITION SWITCH
STARTER SWITCH
STORAGE BATTERY 3 CELL - 6 VOLT.
LIGHTS
LIGHT SWITCH

***The cut-out:** The proper charging of the battery is automatically regulated by the cut-out. When the car speed becomes approximately 7 miles per hour, the dynamo armature will give a voltage sufficient to charge the battery. The circuit between the dynamo and the battery is normally open, but when the voltage of the dynamo becomes proper for charging, the coil (A) (figs. 8 and 9) on the magnet core (B) magnetizes the core sufficiently to attract the arm (C). This arm moves toward the core (B), and thus two spark-proof points (DD') are brought together, establishing the circuit between the battery and the dynamo, and the dynamo begins to charge the battery.

In case the engine speed becomes so low that the dynamo voltage is less than that of the battery, the magnetism caused by the "cut-out" coil (A) is weakened so that the spring (K) pulls the contact (DD') apart. Thus the circuit between the dynamo and battery is opened by the "cut-out" when the dynamo speed is too low for proper charging, and closes the circuit when generator is running fast enough to charge battery. See page 344 for more detail of the "cut-out."

***Current regulator:** In a dynamo the voltage increases with the speed, unless a method of controlling it is adopted. The dynamo should charge at about 7 miles per hour, but it is desirable that when the car runs at a much higher speed, as 15 to 60 miles per hour, the dynamo voltage shall not increase. If allowed to increase, such an excessive dynamo voltage would tend to cause sparking at the brushes, excess current and consequent trouble at the commutator, and excessive wear and heating of the bearings. It would also cause an excessive amount of current to flow through the battery. To prevent this the strength of the dynamo field (fig. 9, page 344 and this page), and consequently the output of the dynamo, is made dependent on the touching of the two points (EE') of controller or "regulator" as follows:

All of the generator current must pass through the coil (F) on controller or "regulator," on its way to cut-out and battery. If this current becomes a certain amount (usually in practice ten amperes) the core (G) becomes sufficiently magnetized to attract the finger (H). This separates the contacts (EE) and a resistance (M) is inserted in the field circuit, weakening it. This causes the amperes to decrease. When the current decreases to a predetermined amount (say 9 amperes) the coil (F) (figure 9) does not magnetize the core (G) enough to overcome the pull of the spring (J). The spring (J) pulls together the points (EE'), the full field strength is restored, and the current tends to increase. Under operating conditions the finger (H) automatically and rapidly vibrates at such a rate as to keep the current constant.

As a result the dynamo will never charge above a predetermined amount (10 amperes) no matter how high the speed of the car, but at all speeds greater than a predetermined speed (about 15 miles per hour in practice) the dynamo will produce a substantially constant current.

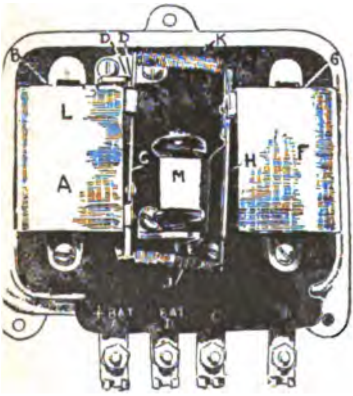
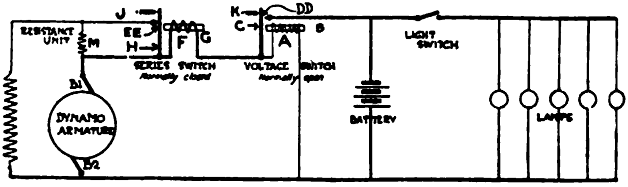


Fig. 8. The Automatic Controller. A—cut-out. F—regulator.

Fig. 9.



HART NO. 168—The Ward-Leonard Starting, Generating and Lighting System using a magnetic principle of "Cut-out" and Current Regulator.

When studying this system don't confuse the "cut-out," which is termed a "reverse current cut-out," with the "regulator." Also note page 344 for more detail of "cut-out." The "cut-out" merely opens or closes cir uit between battery and generator and the "regulator" controls the current output.

Starting Motor, Generator and Ignition—how combined or separated.

A "three unit" system, is shown in fig. 3, chart 167. Here the generator is one separate unit and the starting motor and ignition each, separate.

A "two unit" system, is shown in fig. 2, here the starting motor is in one unit and the generator and ignition another or the starting motor and generator could be combined and the ignition separate.

A "single unit" system, is where the three are combined in one; starting, generating and ignition.

The different systems in general use will be treated farther on. It will be advisable for the reader to study each carefully and then determine in his own mind, after reading the description of each system, the following points: (1) **Is it a single, two or three unit system? (2) How driven? (3) Is starting motor and generator combined, if so how? (4) What method is used for regulating current output? (5) How is the ignition system driven? (6) Is the ignition timer the type shown in fig. 2 or fig. 3, page 242?**

Example of a Modern Starting, Generating and Ignition System—see chart 168.

The starting motor in this particular instance (page 342) is a 6 volt "series" wound motor fitted with the **Bendix** drive as explained in fig. 8, page 326 and 331. It drives through the fly wheel as shown.

The starting switch used with the Bendix drive is the push button type which can be operated by hand or foot. There is no resistance in connection with this switch and when pressure is applied to the button full current of the battery is at once impressed on the starting motor. The switch contact is held only for an instant.

To start engine, press the button of starter switch. The pinion on the end of armature shaft then meshes with the gear on fly wheel, as explained in chart 160.

As engine crank revolves, the generator armature revolves, which turns the timer and distributor shaft (see Atwater-Kent systems, chart 117.) The current from the storage battery supplies the ignition current, which passes through the high tension coil. The engine then starts and continues to run on its own power.

After engine starts, the starting motor has served its purpose and is now idle and is not used until starting is again necessary.

The generator begins to generate current the moment its armature is started in motion by the gear from cam shaft (quite often a silent chain) but does not generate sufficient current to overcome the voltage of the battery until speeded up, say from 7 to 10 miles car speed, therefore the battery supplies current for the ignition (lights also, if on), until the generator attains sufficient speed to generate sufficient voltage to overcome the voltage of storage battery, at which time the generator supplies current for ignition and lights and begins to charge battery.

The automatic cut-out (see chart 168), disconnects the battery from generator when engine is running slow or not at all and connects the generator with battery when generator is running at sufficient speed to overcome the battery voltage. This cut-out is explained in chart 168 also see figs. 1, and 2, chart 163 and note how the battery "floats on the line." This contact lever C, fig. 8, chart 168, vibrates back and forth, owing to the speed of engine.

Ward-Leonard "constant current" regulator: Amount of current supplied to battery is governed by the "regulator" as explained in chart 168. On this particular type of regulator, **note how resistance (M) is inserted into the field circuit of generator** thereby weakening it. This causes the amperage to decrease. If it decreases say below 9 amperes, the contact is closed. If it increases above 10 amperes, the contact is opened, throwing in the resistance (M) again, and in this way the amperage output is kept fairly constant. This would be termed **constant current regulation but with an external type of regulator** instead of inherent type.

Difference between the "cut-out" and "regulator" is exemplified in chart 168.

The cut-out principle explained in this chart would be called the "automatic," or "magnetic" or "vibrating" type principle of the reverse current type.

The controller of the Ward-Leonard system consists of the "cut-out" and "regulator" mounted together as in fig. 8.

A careful study of chart 168 will make the principle of this system clear.

Different Regulation Methods.

We might class the different methods of regulating the voltage and amperage of a generator under three heads; (1) constant current with inherent regulation; (2) constant current with external regulation; (3) constant voltage or potential regulation.

Inherent Constant Current Regulation.

Inherent or constant current regulation is so named, because its method for regulating the current or amperage output does not depend upon external agents, as a separate mechanical regulator, etc., but its connections are embodied **internally,** into the generator proper. With this system, the current output is constant but voltage slightly varies, see page 925.

The inherent or constant current regulation control may be a "third-brush" system, "bucking series," that is, a differential compound winding, or "cumulative" compound winding, or a "thermal" principle, all of which would come under the head of "constant current" or "inherent" methods of regulation.

Third brush regulation: This principle is explained on pages 925 and 389, and consists of a third brush, which regulates the output. It is used quite extensively and

—continued on page 345.

The internal wiring of the Ward Leonard controller is shown in Figure 9

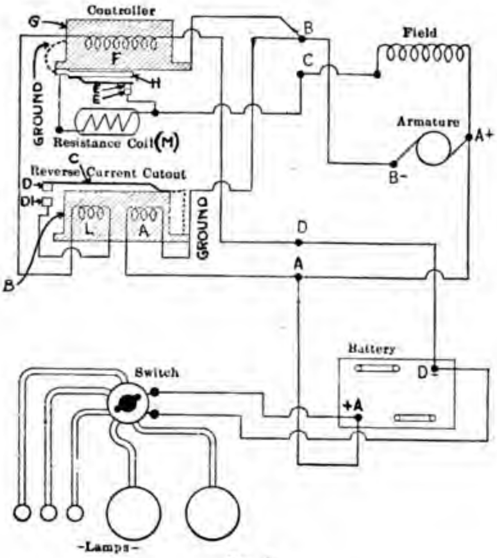


Fig. 9

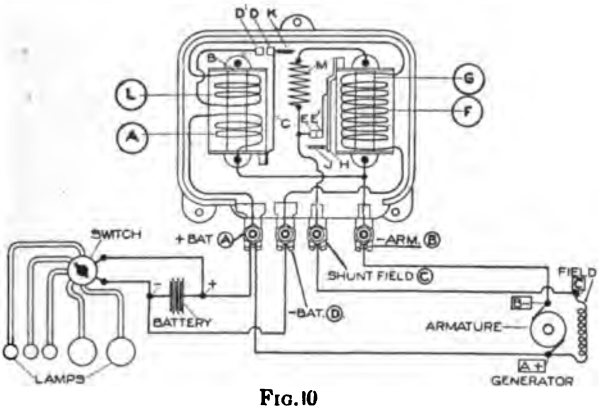


Fig. 10

Explanation of cut-out and regulator circuit: The path of charging current is from (A+) on generator, to A on cut-out, thence through battery to (D) on regulator, thence through windings (F and L) to contact point D1, across D1 to D, then down lever (C) to magnet frame, then from ground connection on magnet frame to part (B) of controller and from there to (B—) of generator—thus completing the circuit. The purpose of resistance (M) is explained on page 342.

Circuit Details of the Ward-Leonard "Cut-Out."

Although the subject was dealt with in chart 168, the winding (L) and other "cut-out" diagrams were not fully explained. By referring to illustrations on upper, right hand illustration of chart 168, and fig. 10, this page, note there are two coils (L and A) wrapped on the core (B); one "shunt" (A), and one "series" coil (L). This iron core (B) attracts and repels an iron lever (C). Attached to this lever (C) are contact points (D) at which the contact between the generator and battery is made and broken. **The shunt coil** (A) is connected directly across the two brushes of generator and therefore the full generator voltage is impressed across the ends of this coil similar to (P) fig. 2, page 334.

The series coil (L) of cut-out is connected in "series" with battery and generator through controller or current "regulator" coil (F). The current from generator, to charge battery, must pass through the "regulator" coil F.* Therefore, this series coil (L) of cut-out carries the charging current when battery is being charged—fig. 2, V, page 334 will probably make this idea clear.

Why Reversal of Current In Cut-Out Coil L.

The coil (L) is employed to insure perfect **de-magnetization** of the core (B) on reversal of current, so it will release blade (C) quickly, explained as follows:

When the engine is **started**, the generator is driven by the engine, and it, therefore, increases and decreases in speed with the engine. When the engine is speeded up the generator follows with corresponding **increase** in speed and the voltage of the generator rises as the speed increases. As soon as the generator voltage gets to a point above the voltage of the battery, which is approximately six volts, the shunt coil (A) **pulls** the iron lever (C) towards the magnet core, thereby **closing** the contact at the points (D). As soon as this **contact is made**, the generator is connected to the battery, and **a charging current** will flow from generator to the battery through the series coils (L) and regulator coil (F) which are in series with the generator and battery. The generator continues to charge as long as contact points (D) remain together, but when the engine speed is decreased, so that the generator voltage **falls** below the battery voltage, the battery will discharge through the generator and therefore through the coil (F); under **discharge conditions** current flows through winding (L) **in the opposite direction** to that which it does under **charging conditions**. While in the winding (A), the flow of current is in the same direction. This **reversal of the flow of current in (L)** causes the winding to buck or work against each other, therefore **demagnetizing** the core (B) which allows the spring (K) to pull lever (C) **away** from the magnet core, thereby opening the contact at the points (D), which disconnects battery with generator.

CHART NO. 168A—Detail Explanation of the Ward-Leonard "Cut-Out," Called a Reverse Current Cut-Out, the reason of which is explained above.

*See page 343 for explanation of the "regulator" coil (F). This part of the controller is to regulate the output of generator, whereas the "cut-out" merely opens and closes circuit between battery and generator.

comes under the head of inherent or constant current regulation.

Bucking series regulation: This method would also come under the head of inherent or constant current regulation. A simple explanation of the working of the "bucking series" winding is given below.

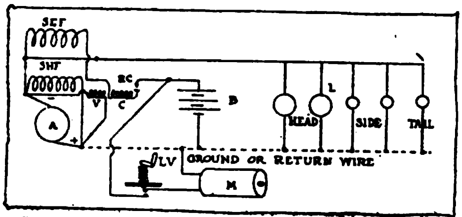


Fig. 1.—Wiring diagram of Westinghouse six-volt system, showing grounded return wire with "bucking-series" method of regulation.

Machines of this type are essentially differential compound generators with internal connections such as shown in fig. 1. The series field (SEF) increases in strength with increase of output and opposes the shunt field (SHF), thereby reducing the resultant field and keeping the voltage and current within permissible limits. A separate mechanical regulator is not used.

With this type of generator the storage battery really regulates the voltage and the series winding and speed of generator determines the current or ampere output.

*A reverse current cut-out (RC) is provided and is so adjusted that on the average car the battery circuit is cut **in** above 10 miles an hour and cut **out** below 7 miles.

When the generator is connected to the battery by the automatic switch (RC) the current rises rapidly with the speed until a value of from 5 to 7 amperes is obtained if the lamps are not burning. Above this, the output rises very gradually, the curve being nearly flat for all motor speeds so that the danger of an excessive charging rate to the battery in day touring, when lights are off, is eliminated. The idea is that the current comes primarily from the shunt field winding and should be kept as nearly constant as possible, although the speed of generator is increased or lamp load is added.

This is accomplished by what is termed the **reversed** compound field windings on the generator, or the addition of a **series coil** which has a **bucking** or opposing effect to the flow of current in the shunt coil winding. This effect is obtained, by causing the curent in the series field coil (SEF) to flow in **such a direction** that its effect on the magnetic field of the generator will oppose the effect on the magnetic field of the shunt field (SHF).

For example: when the lights are turned on the output of the generator increases proportionately, explained as follows: assume that the lamp load requires 6 amperes and the generator output is 5 amperes, then 1 ampere must be **taken from the battery.** This **battery current must go through the series field** (SEF) on its way to the lights in order to complete the circuit, thus it **assists** the shunt field (SHF) instead of bucking it, therefore the current value will rise as lamp load increases, but not excessively, as the bucking effect will come into action and prevent it, explained as follows:

Now assume that the generator output is 7 amperes and the lamp load is 6 amperes. This leaves 1 ampere which will now be **taken from the generator** to the battery, to charge it. This 1 ampere must pass through the series field (SEF)—but will pass in a **reverse** direction to what it did when it came from the battery—this change of direction through the series coil causes the series coil to buck or oppose the shunt field (SHF) instead of assisting it, as in the above case. Therefore, as the speed increases the effect of the series coil bucking or opposing the shunt coil and the de-magnetizing effect of the armature current will be more and more pronounced and thus prevent excessive current rise as the generator speed is increased to relatively high values.

The effect of this action is to proportionate to the speed of the generator and to the quantity of lamp load **so that at all times the output of the generator will be greater with lamp load than without.**

Series bucking coil and thermal method of regulation: Another method of causing the series coil to buck the shunt coil is by means of a thermal principle, explained on page 339. The difference here is in the addition of an iron wire ballast or thermal coil which permits the current to flow through it and not through the series coil at low generator output, but as generator output increases the iron wire heats and offers resistance and current must flow through the series coil which then bucks the shunt coil and thus regulates the output fairly constant. This would be termed an inherent method of regulation—although, the iron coil is placed separate from generator, the action is not mechanical.

A cumulative compound winding is shown in fig. 4, page 351 and explained on page 347.

Constant current regulator of the external and mechanical type is shown on page 342. Instead of the current being regulated internally (inherent), it is regulated by an external regulator which cuts resistance in and out of field circuit. It is similar to a voltage regulator, except the magnet coils are wound to regulate the output for constant current instead of for constant voltage (don't confuse the battery "cut-out" with the regulator).

Constant Voltage or Potential Regulation.

An external device is used, known as a "voltage regulator" which operates mechanically. The voltage is kept constant but the current output varies with this system, as explained on page 925.

The voltage is regulated through a range which permits the charging of a storage battery at a high current rate when battery voltage is low, and at a much lower rate when battery voltage is high. In other words, the **charging current depends upon the state of charge of the battery** or its specific gravity. A nearly discharged storage battery will take a heavier charging current, which charging current will be reduced as the battery becomes charged.

***Don't confuse the action or purpose of the battery** cut-out (called a reverse current cut-out, principle of which is explained on page 344) with that of a current regulator or voltage regulator. In fact a cut-out is used with either the voltage or current regulation system, however, on some constant current systems, Delco, for instance, the cut-out is eliminated. (see page 383.)

See page 925 about removing battery with a constant current and a voltage regulation system and note difference.

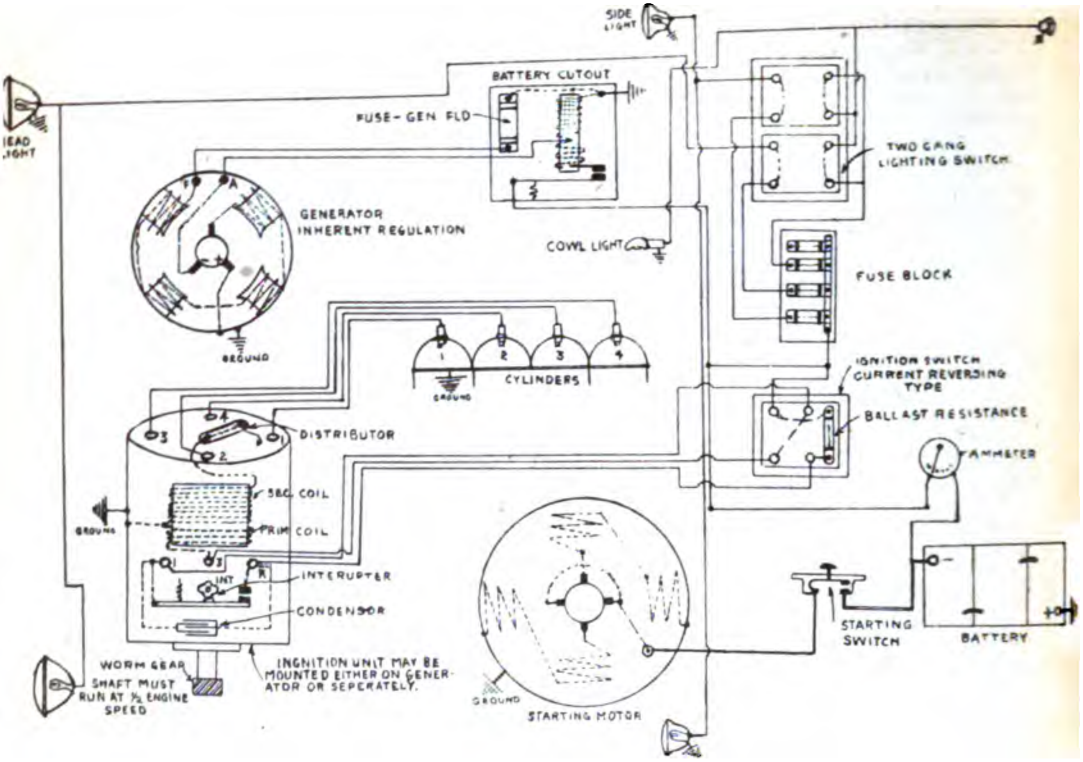


Fig. 1. Westinghouse starting, generating, lighting and ignition diagram. Note the complete ignition unit is mounted on the generator. The starting motor is separate.

The generator in this instance is a 6 volt generator which can be driven by a silent chain or gear drive.

The cut-out is shown, which is of the usual **reverse current** type of relay (note relay and cut out are synonymous). It's purpose is to open and close the circuit between the battery and generator as explained in charts 168 and 168-A.

The regulation of this generator is called the "inherent" system, which is similar to "current" regulation and is different from voltage regulation. Note the "ground" to the generator frame.

The single wire or **ground return,** using the frame of the car is employed.

The starting motor is of the series wound type, with ground to motor frame.

The Westinghouse vertical ignition equipment consists of a vertical ignition unit as shown in this, and chart 168-C, diagram fig. 7. An ignition switch, a ballast resistor and a battery.

Equipments are made for 6 or 12 volt circuits and for use on 4, 6 or 8 cylinder engines. The system shown in this chart and 168-C is a 6 volt battery and generator.

The ignition unit is made up of four essential parts, namely, the interrupter (IC, connections to it), the condenser (see fig. 1), the induction coil (C, and fig. 1), and the distributor (D), all included in one case.

(see also pages 347, 348.)

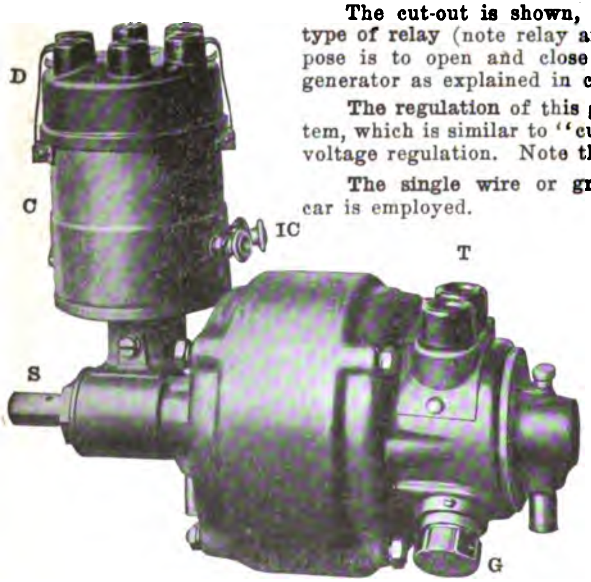


Fig. 2. Westinghouse generator with the ignition distributor and timer and high tension coil mounted on the generator. The coil is beneath the distributor and timer. The generator is driven by a silent chain from cam shaft, the distributor shaft is driven from a spiral gear on armature shaft (S), and is of course driven at cam shaft speed. T, generator terminals (see fig. 1, F-A); G, ground connection terminal.

CHART NO. 168B—The Westinghouse Starting, Lighting and Ignition System, using a Reverse Current type "Cut-out" between Battery and Generator with an "Inherent" system of "Regulating" the Output of Generator—a "two unit single wire" system.

Westinghouse Vertical Ignition Unit Mounted on Generator.

This system is explained in charts 168-B and C. One part which is not fully explained in charts is the Ballast resistor. Its purpose is explained below.

The ballast resistor† (see chart 168-B and C) has a resistance, having a high temperature co-efficient, placed in series with the primary coil of the ignition unit. This resistance with the resistance of the coil keeps the primary current at the correct value when normal voltage is applied. It has many other functions. If the engine is left idle with the ignition switch on, the resistor gradually heats up causing its resistance to materially increase and cut down the primary current. (see also "ignition resistance unit," page 378). This decreased primary current very much reduces the probability of burning at the primary coil.

When the engine is running a certain amount of primary current will flow at each closing of the contacts. As the engine speed increases the time of contact is shortened and the time allowed the primary current to build up materially reduced. As this current reduces in value the resistor tends to cool, consequently reducing the value of the resistance. In this way the total resistance of the circuit is reduced and the current in the primary coil may be built up very rapidly.

The Mechanical Governor Control.

The model of starting motor used in the 1914 Overland, in this instance, chart 170, is used as an example in order to bring out the **unusual driving method** and action of a **roller type** of clutch. Also to bring out the action of the **mechanical governor** principle of controlling the output of generator current.

The drive in this instance, is by means of a double sprocket which "over runs" the roller clutch (D), which is the starting motor driving member. After engine is started, the generator is then run by engine crank through a chain, to double sprocket which "over runs" the clutch (D). (see chart 170.) Other methods of drive could be employed.

The "roller" type of clutch is used on many different systems and it will be worth while to study its action.

The clutch on the governor of the generator (fig. 3) is of the "friction" type actuated by centrifugal motion, and is a different principle from the "roller" clutch.

*Cumulative Compound Winding.

The generator is compound-wound with a shunt field, SHF, and series field, SEF, fig. 4, page 351. Unlike most compound-wound machines used for electric lighting the two field windings assist one another instead of oppose as per fig. 1, page 345. For this reason this is called by the electrical engineer a "**cumulative**" compound instead of "differential" compound machine; that is, it is so wound that the output of the dynamo increases as more current is required. This provides an automatic control of the load.

The purpose of the additional field, SEF, is to increase the output of the generator as the lights are turned on, without increasing the speed of the generator. For example, with all lights out, the generator will deliver about 6 amperes, while with all lights burning it will develop 12 amperes. Between these two points it will deliver additional amperes in proportion to the number of the lamps burning, that is, with half the total number, 9 instead of 12 amperes will be the output.

This Gray and Davis generating system employs the usual type of automatic **magnetic** "cut out." The later Gray and Davis system is explained in chart 173.

The Mercury Type Regulator.

This system is now seldom used, but will be explained in order to show the first principles of a Delco motor-generator and the "mercury" method of regulation.

In order to clearly understand the system it will be necessary for the reader to study the principle of the entire 1914 system. For explanation, see chart 186.

How One Armature Serves for both a Motor and Generator.

The Delco system, explained under instruction 28A, is a system of this type.

Another system, using the same armature for motor and generator was the "non-stallable" Entz system formerly used on the Chalmers. (see page 352.)

This Entz motor-generator system consists of the following parts: (1) storage battery 18 volts, 9 cells. (2) motor-generator. (3) shaft with universal joint to start engine and drive generator (fig. 3, chart 164). (4) silent chain running in oil connects the motor generator drive shaft with engine shaft by means of a sprocket located just ahead of the flywheel. (5) a switch on the dash which opens and closes the circuit.

U. S. L. Graphite Pile Regulator.

The generator takes the place of the fly wheel. The construction and principle is shown in chart 172.

The regulation of the 1914 system was similar to the system explained in chart 165. Instead of "resistance wire" being cut into the field shunt winding, in this instance "graphite" piles are used. Graphite offers resistance to the flow of current, therefore the same effect or principle is the result—weakening of the field current at high speeds. This regulation system is not used on the later models of the U. S. L., but is merely shown in order that the reader will understand the principle.

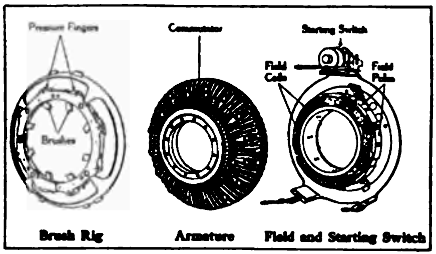


Fig. 1: Parts of the U. S. L. fly wheel type of Generator.

---

†See pages 337 and 345, for explanation of "constant current" or "inherent" regulation and "voltage" regulation. ***The "differential" compound winding** is explained on page 345. The difference between "cumulative" and "differential" winding is explained on this page.

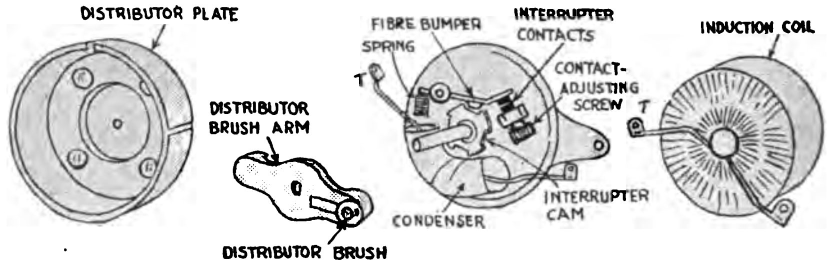


Fig. 1. View of the parts of the Westinghouse ignition unit as per page 346. See also page 251 and 252.

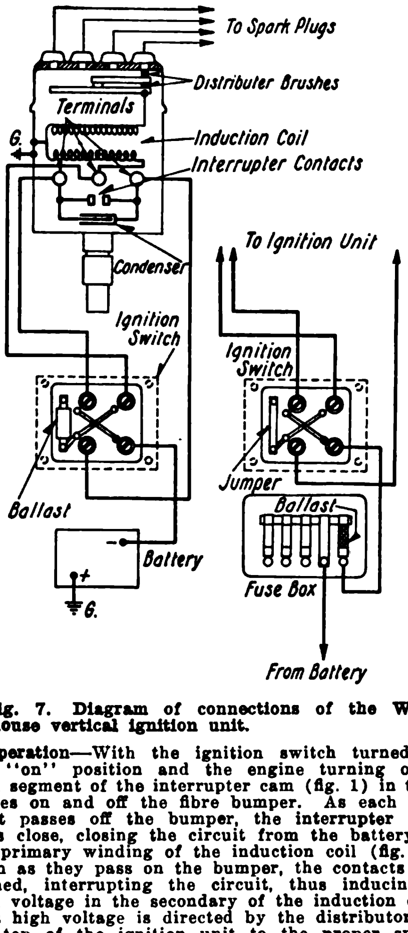


Fig. 7. Diagram of connections of the Westinghouse vertical ignition unit.

Operation—With the ignition switch turned to the "on" position and the engine turning over, each segment of the interrupter cam (fig. 1) in turn passes on and off the fibre bumper. As each segment passes off the bumper, the interrupter contacts close, closing the circuit from the battery to the primary winding of the induction coil (fig. 7). Then as they pass on the bumper, the contacts are opened, interrupting the circuit, thus inducing a high voltage in the secondary of the induction coil. This high voltage is directed by the distributor on the top of the ignition unit to the proper spark plug, causing a spark as it jumps the spark gap of the plug inside the cylinder, and igniting the charge therein.

The ignition switch is double-pole with the internal parts so arranged as to reverse the direction of current through the interrupter with each operation of the switch. The reversal of current principle and purpose is explained under "polarity switch," page 248.

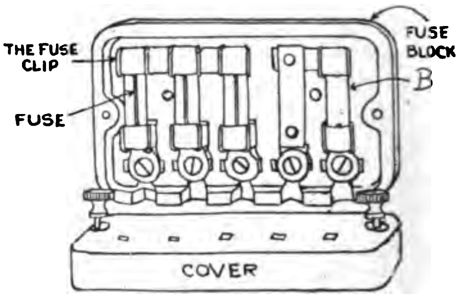


Fig. 4. Fuse block with ballast resistor. The fuse block and ballast resistor (B) may be combined in one unit or separate. Instead of the ballast resistor being on the back of the switch as in fig. 3, it can be placed along side of the fuses protecting the lighting current.

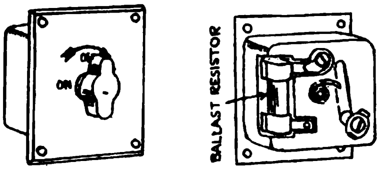


Fig. 3. Front and rear view of the "ballast resistor" on the back of the switch (fig. 2). Purpose of which is to protect the ignition interrupter points from burning. A 5 ampere fuse may be used to relieve an emergency but ignition must be turned "off" when engine is not running. (See page 347, explaining the "ballast resistor.")

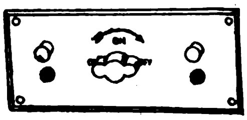
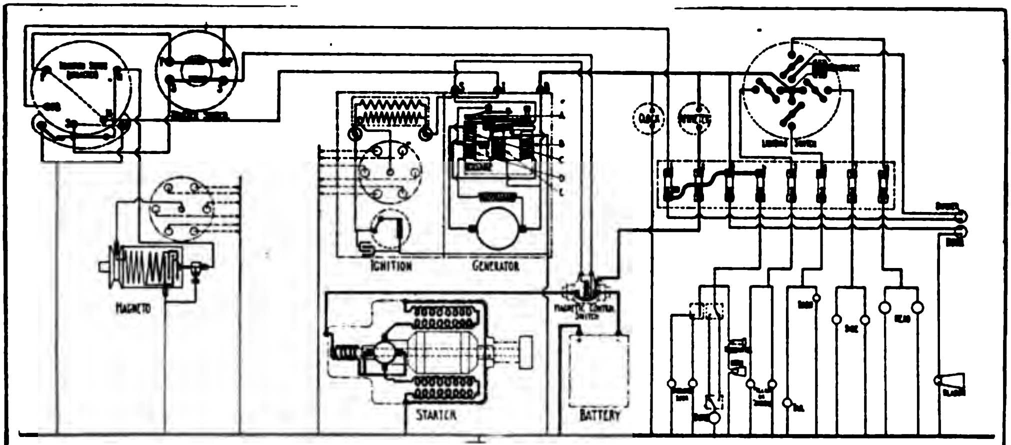
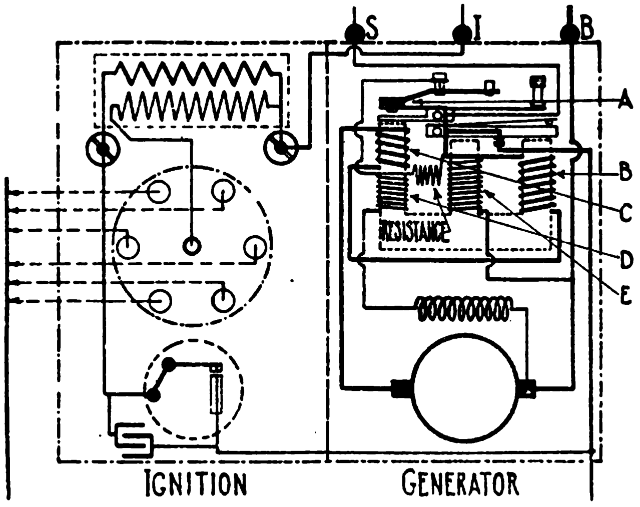


Fig. 2. The double pole ignition switch arranged so it will **reverse** the direction of **flow** of current through the interrupter, see page 248, explaining the function of a "polarity" switch also called a "current reversing type" of switch also note lighting switches.

CHART NO. 168C—The Westinghouse Battery and Coil Ignition System as used with the electri system shown on page 346. See also pages 251 and 252.



WIRING DIAGRAM OF C4 AND B4 MODEL PIERCE ARROW



This generator is an ordinary shunt wound machine, with a separate **voltage regulating device**, and differs from the previous machine, which had differential field windings. To explain this type generator in brief, would say that it has a cutout switch which operates exactly on the same principle as did the switches on the elder machines, but in addition there is a device for throwing a resistance into the field circuit from time the voltage rises above a predetermined point, 6.8 volts.

Voltage regulation: The shunt field current goes from the right hand brush up through the shunt field, through coil "D," then up and across the voltage regulating points "A" and down through the series coil "B," series regulating coil "C" and back to the other brush of the generator. As the voltage tends to go high, the current flowing through coil "E" and "C," and consequently the magnetic pull of core "C," becomes of such magnitude that points "A" are pulled apart. In such case the shunt field current has to pass from coil "D" through the resistance unit and then through coil "B," coil "C" and to the other brush. With the resistance in the shunt field circuit, the voltage tends to drop below six volts, but as soon as this drop starts the points "A" close again and boost up the voltage. These breaker points "A," vibrate at a high rate of speed and in doing so hold the voltage at the correct value. The coil "D," used in connection with this vibrating voltage regulator, is a compensating coil, used to offset the effect of stray fields set up by the generator.

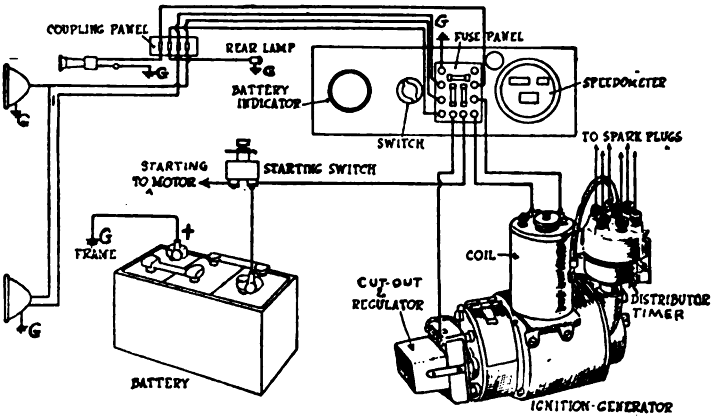
The cutout switch: Current leaving the right hand brush of the generator passes through the shunt cutout switch coil "E" and then through coils "B" and "C" and back to the other generator brush. This is the usual type of cutout, similar to the Ward-Leonard shown in chart 168.

Westinghouse ignition unit is composed of a very compact high tension coil with a mechanical breaker in the primary circuit operated by a cam on the end of the generator shaft. High tension current is led from the coil to the high tension distributor and then from there to the plugs. The coil and distributor units are built up in one housing and electrical connections are established with terminals of the generator by means of the two screws holding this housing in place. Primary current going to the ignition unit goes from one terminal of the battery to one side of the magnetic control switch, then up through the main lead for the lighting switch, first going through the 30 ampere fuse and then through the ammeter. From the ammeter, ignition current goes down to the top of No. 3 fuse and then across on the copper strap to the bottom of No. 1 terminal post in the fuse box. From here it passes up through the small resistance unit of .6 ohms and from there to the point "PB" on the ignition switch. When the ignition switch is thrown on "B" or "MB," positions, then "PB" and "IG" are connected. From "IG" on the switch the current goes directly to the central terminal "I" of the generator and then through the primary winding of the H. T. coil, down across the breaker points to ground and back to the battery. Note that when the dash starting button is pushed that in addition to closing the starting circuit, by connecting the two points "SS" it also connects the points "P" and "PB" on the ignition switch; and point "P" is connected to point "IG" whenever the switch is unlocked. Thus whenever the engine is started with the ignition switch on magneto position, the battery system of ignition is in action as long as the starter button is held down.

The ignition switch, aside from the connections noted above to be used when starting, has an additional magneto ground, which is operated by pushing against the switch lever when same is in magneto position.

Starting motor: Current goes from the battery across the magnetic control switch to the solenoid mounted at the front end of the motor. When current passes through this solenoid it pulls the starting pinion into mesh with the flywheel. From the solenoid the current passes to one pair of motor brushes, through the armature winding, to the other pair of brushes, and then through the field windings to ground to the battery. (Similar to chart 161.)

The electric clock: The electric clock is wound up by energizing a small electro magnet, which operates every four and a half minutes; in other words, this clock will not run more than four and a half minutes after



Remy Electric System.

Type:—Two unit. **Voltage:**—6. **Voltage regulation:**—Third brush and vibrator.

The equipment varies with each make of car, but that used on the Velie may be taken as an example.

Ignition Coil:—Mounted on top of generator. **Distributer and timer:** at one end, geared to armature shaft. **Cut out or relay:**—at other end.

Wiring—The negative line brush is insulated from the metal rocker ring, while the positive line brush and the field brush, are connected to it, the circuit from the battery to these brushes being through the frame of the generator.

The cutout and regulator are combined on the same Bakelite base. As soon as the generated voltage is greater than that of the battery the cutout points close.

The regulator consists of an electro-magnet, an arm operating on bronze pivots, two sets of contact points and a resistance unit.

When the generator is running at a speed lower than that required for maximum output, the contact points are held together by a spring and current supplied to the generator field passes directly through these points.

As soon as the speed increases and the generator output tends to rise above the desired maximum, the contact points are opened, forcing the field current through a resistance, consequently reducing the strength of the current with the result that the voltage generated is limited. This action takes place with such rapidity that the voltage actually remains constant at the prescribed maximum.

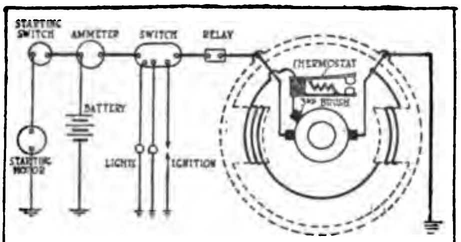


Diagram of connections with Remy thermostat

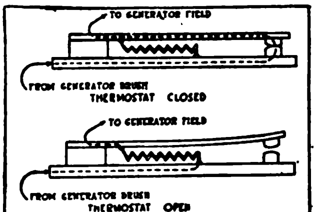


diagram of connections for Remy automatic output regulating thermostat

The Remy automatic regulator controlled by the temperature, which switches a resistance into the field windings as soon as the temperature of thermostat rises above 150 degrees. Normally the contacts are kept together, but when **thermostat element is heated,** the points separate. The resistance (shown between the two springs) is then thrown into the field circuit.

Fuse—A fuse is provided on the regulator base so that the generator will be protected in case the battery should become disconnected.

Ignition—The breaker gap should be .02 or .025, and the rebound spring should be at least .02 in. from the breaker arm when the points are at maximum opening. Spark plug gaps for best results should be .025 to .03 in. (also see chart 118 and page 251.)

It is important to see that ignition switch is off whenever engine is stopped, as otherwise the **battery** will discharge. **The engine should never be operated while battery is disconnected unless the generator fuse on the regulator-cutout is removed.**

Troubles.

If lights, ignition, starting motor and horn are dead the cause may be a loose or broken connection at the battery terminals, or where the battery is grounded to the frame; a loose or broken connection at the starting switch or at the starting motor, or wire between the battery and fuse block; a loose or broken connection at the starting switch or starting motor or wire between the fuse block and the lighting switch broken and either fuse No. 1 burned out or the horn open-circuited.

If all lights go out and ignition and starting motor are dead, there may be a loose or broken connection at the starting switch or starting motor.

If all lights go out and ignition and horn are dead the difficulty may be a defective connection between the battery and the fuse block or between the latter and the lighting switch and either fuse No. 1 being burned out or the horn open-circuited.

All lights out and ignition dead shows that the wire between the fuse block and the lighting switch is defective or that the ignition circuit is open, and either fuses Nos. 2, 3 or 4 are burned out.

If the lights are inoperative but the ignition is o. k. the trouble is in the wires between the lighting switch and the fuse block, fuses 2, 3, 4, and the wires to the lamps.

If the ignition is dead and the lights are o. k. the trouble is somewhere in the ignition wiring.

If the lights go dim and the battery is not discharged and after examining the bulbs to see that they are not of lower voltage, greater candle power or lower efficiency, look for a short circuit in the wire between the battery and the fuse block, between the fuse block and the lighting switch or between the switch and the generator. If the generator protective fuse is blown, look for a short circuit, but if not examine the cutout.

CHART NO. 169—The Remy Two Unit Electric System. **The Starting Motor is not shown,** but the **Starting Switch and Connections are shown. One wire from switch connects with starting** motor terminal, the other terminal of motor is grounded and circuit is completed through frame of car. **Remy Electric Thermostat.**

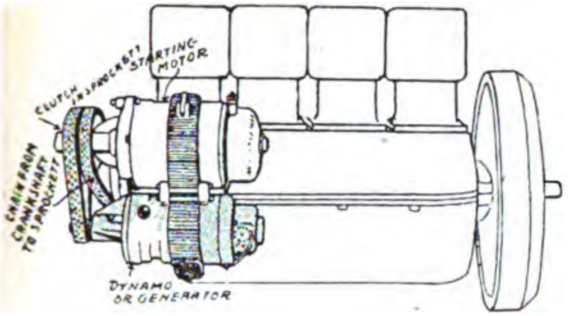


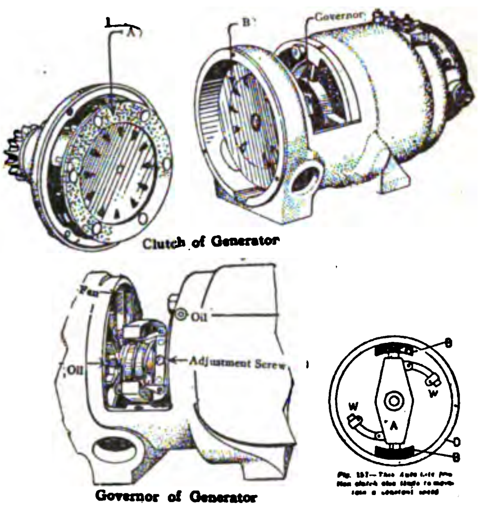
Fig. 1. The 1914 Gray & Davis Starting Motor, connected to the side of engine. A double sprocket with a roller clutch transmits the drive to the crankshaft of engine by a chain.

The dynamo or generator is mounted directly under the starting motor, and is driven by chain from the double sprocket.

After starting motor starts engine, the dynamo continues to run, but the clutch on sprocket permits the double sprocket to revolve without revolving motor.

Starting Motor is geared by means of reduction gears in end of motor case (A & B).

The Ratio of gearing is 28 to 1.



Clutch of Generator

Governor of Generator

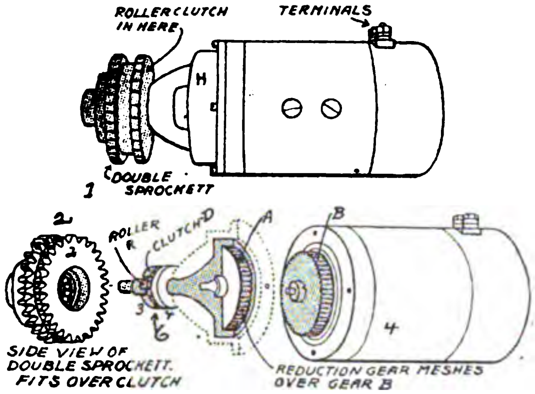
Fig. 3—Gray & Davis Generator with Mechanical Governor. (See text for electrical action of regulation).

The regulation of current (amperes) output is accomplished in two ways: Electrically, by compound winding in field and Mechanically by a Governor.

The regulation of maximum output is effected by the centrifugal governor, which keeps the speed of the machine constant. For that reason this may be placed in the class of mechanically regulated machines. Variations in speed are taken care of by the automatic clutch.

The clutch (A & B) will slip more or less according to the speed of the engine, and the amount of such slippage is controlled by a governor.

As soon as the speed of the armature increases beyond the rated number of revolutions, the governor will act on the friction clutch. In other words, the two clutch halves (A & B), will be pulled apart and slip in such a manner that the armature will rotate not faster than the pre-determined speed.


ROLLER CLUTCH IN HERE
TERMINALS
H
DOUBLE SPROCKETT
1
2
2
ROLLER R
CLUTCH D
A
B
3
6
4
SIDE VIEW OF DOUBLE SPROCKETT. FITS OVER CLUTCH
REDUCTION GEAR MESHES OVER GEAR B

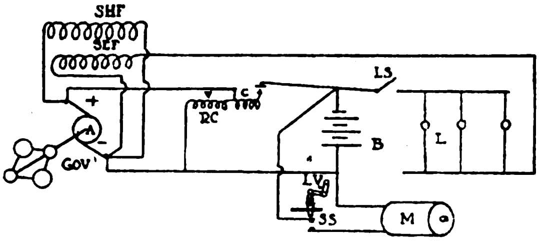


Fig. 4.—Gray & Davis Wiring Diagram.

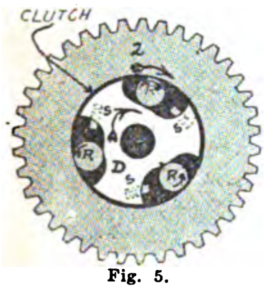


Fig. 5.

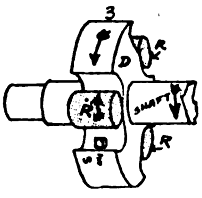


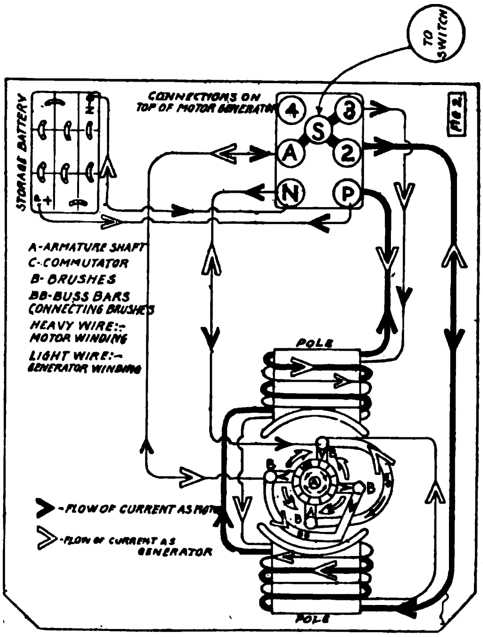
Fig. 6.

Action of Roller Clutch: (D) is connected to motor armature shaft at (3 & 6). When motor shaft revolves by current from battery, (D) turns in direction of arrow point, causing rollers (R), to clutch against inner surface of sprocket (2).

After Engine is Started and motor switch is off, sprocket (2) then becomes the driving member; causing roller (R) to roll in opposite direction, thereby releasing its clutch.

The Double Sprocket (2), then over rides (D), and starting motor is idle.

CHART NO. 170—The Gray and Davis Starting and Generating System. Roller type clutch explained. This system is out of date, but used to explain the "mechanical governor" an "roller" type clutch. This type of clutch is used to a considerable extent and is also explained in Delco Instruction. See page 347 for explanation of fig. 4, generator winding


TO SWITCH
STORAGE BATTERY
CONNECTIONS ON TOP OF MOTOR GENERATOR
4
3
S
A
2
N
P
Fig 2
A-ARMATURE SHAFT
C-COMMUTATOR
B-BRUSHES
BB-BUSS BARS CONNECTING BRUSHES
HEAVY WIRE:- MOTOR WINDING
LIGHT WIRE:- GENERATOR WINDING
POLE
B
B
B
A
BB
-FLOW OF CURRENT AS MOTOR
-FLOW OF CURRENT AS GENERATOR
POLE

Entz Motor-Generator.

Operation of Entz self-starter: The operation requires only one movement on the part of the driver—the movement of the starting switch.

Switch: Controls both the starting and the ignition; the same operation makes contact with the primary circuit of the battery, so that the regular cycles of the ignition system will be taken up when the engine begins rotating.

The starter switch is kept in charging position, except when driving for more than one quarter mile below eight miles per hour in high gear; in this case, the switch is set in neutral, throwing the switch back to charging immediately the car increases its speed to over eight miles per hour. Under all other running conditions, regardless of the speed, the switch is kept in charging position.

If the car is left standing for any length of time, the engine is stopped. If it is necessary to keep the engine running, the switch is set in neutral, while the car is standing still. After idling the engine or running slowly for a considerable length of time, the switch is put back in charging position, as soon as the speed of the car picks up.

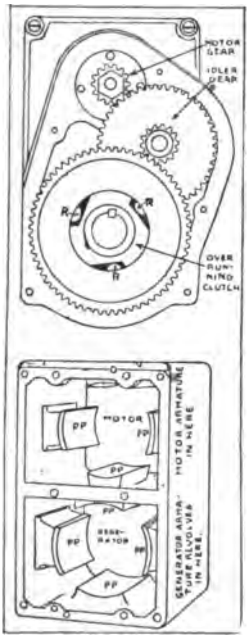
The combined motor and generator of the Entz electric system, is known as differentially wound motor-generator. The series and shunt field coils are connected so they operate **compounded as a motor, differentially as a generator.**

All automatic cutouts, regulators or controllers have been eliminated from the system. There is but **one armature** and one set of field magnets, but two field windings.

The motor-generator is a 4 pole "multi-polar" type of generator, with four brushes. The **motor winding** is the large wire. The other differential winding is small wire wrapped over the large wire and is the **generator winding.**

When starting engine with starting motor, switch is placed "on." It remains on until engine is stopped. When the switch is placed "on" position, the engine is revolved 80 revolutions per minute by the starting motor. (heavy winding of wire).

Above 600 revolutions, the motor is converted into a generator—as above this speed the small wire winding is generating enough current to overcome the 6 volts pressure of battery, hence it stores current into the battery. If, however, the engine is reduced to 80 revolutions or less, the generator again is transformed into a motor, and the generator not overcoming the pressure of the batteries; battery again turns armature as a motor—therefore, the engine is "non-stallable."



In other words, in any circumstances where engine would ordinarily be stalled, immediately upon releasing the clutch pedal the motor will turn engine crank and become operative.

Both the fine and coarse wire winding is wound in the same direction on the field, but current in the heavy wire winding **travels** in opposite direction, due to pressure from battery which tends to reverse the polarity of the fields or "buck the fields." This tendency to **reverse the poles of the field is governed** by the amount of charge or amperage hours in the battery. That is, if the battery is in a discharged condition the fields will build up, causing a greater flow of current through the fine wire, but as the battery becomes charged the fields will become weakened, which condition will cause less current to flow through the fine wire.

The electric light globes are 21 volts, although the battery is but 18. As there is always a slight excess of current from all generators this prevents lamps burning out rapidly. **The polarity switch** (used with the Atwater-Kent ignition system) is explained in chart 117.

Remy "Double Decker" Motor-Generator.

The Remy model 150 exemplifies how a generator and starting motor can be operated one over the other.

Employs two separate armatures and two separate fields, and may be termed a "double decker" since the motor armature is super-imposed over the generator armature.

The two armatures are connected together with a system of gearing and an over-running clutch. (R), see chart 170 for principle). **The motor armature** and the gearing are only in operation when the starting switch is pressed.

The generator armature is the only moving part under running conditions, as the over-running clutch of the roller type is provided to disengage motor armature and reduction gears, which remain idle and inoperative when engine is started and running under its own power. **Generator armature** revolves in lower field. Motor and generator are entirely separate—(armature is drum type). A **regulator and automatic cut-out** of usual type are provided.

CHART NO. 171—The Entz System—formerly used on the Chalmers. **Also similar to Entz system** formerly used on the White. **The Remy "Double Decker."**

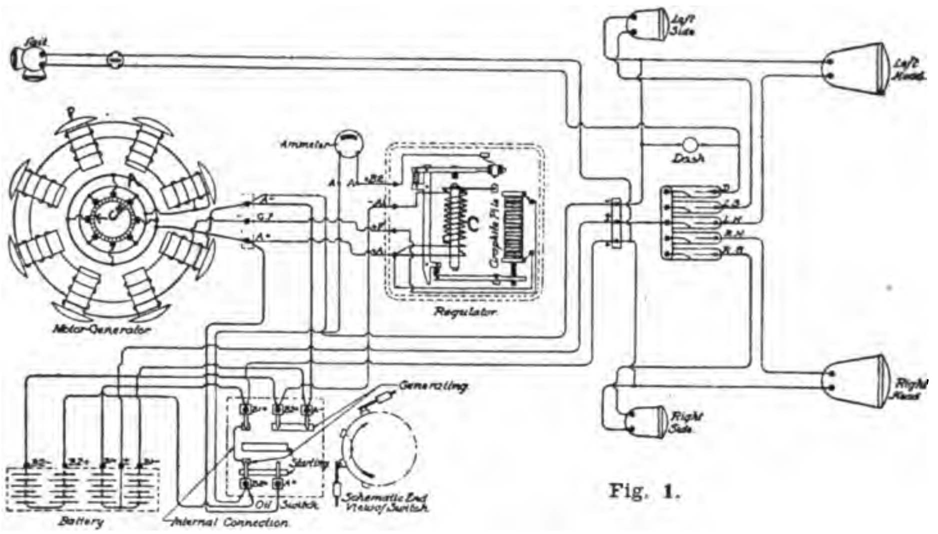


Fig. 1.

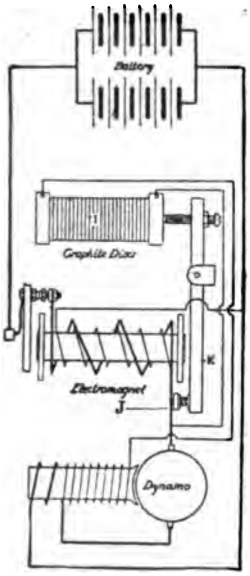


Fig. 2. The regulator of the U. S. L.

The regulation of constant voltage is maintained by pressure upon the graphite discs I, which are pressed together by lever K, by pressure of coil spring J. The less the pressure, the greater the resistance thrown into the field winding, for if the discs are not close and tight, resistance is offered to flow of current. Note the pressure upon these discs is also controlled by the electromagnet, the stronger the current flowing from generator, greater will be the magnetic pull on K and J, thereby taking pressure off of the graphite.

U. S. L. 1914 Flywheel Installation.

The U. S. L. 1914 is a two-unit system. In installing this system the armature of the motor-generator takes the place of the flywheel and performs its functions as well as those of the electric lighting and cranking systems.

The field has two windings, shunt and series. When machine operates as a motor, those windings are cumulatively compounded, that is, magnetic effect of series winding augments that of shunt so as to secure maximum torque. When machine operates as a generator, these windings are differentially compounded, that is, the magnetism of series winding is opposed to that of shunt, so as to assist in regulaton. The voltage of the motor is 24, while the charging voltage of the generator is 12.

The preferred disposition of the units is that shown in fig. 1. As will be seen, the added weight will be only that of the battery, fields, switches and controller as the flywheel is removed and replaced by the armature of equal weight.

When a foot switch is pressed the battery is connected to the motor and this turns over the engine at the rate of from 200 to 300 revolutions per minute.

As soon as the engine picks up to a speed giving 8 miles, the motor-generator becomes a shunt-wound generator and starts to charge the battery, restoring the current used at a 3-ampere rate.

In order that the output of the generator shall be uniform, a carbon or graphite pile regulator, operated by a series coil, C, is used. This keeps the output through the working range of from 600 to 1,200 revolutions per minute, practically constant.

1915 U. S. L. Electric System.

The improved system eliminates the carbon pile regulator and the "series parallel" switch. No regulator is used, as windings of generator are so proportioned, that the output of generator, cannot exceed the current demand of the storage battery and lamps.

A portion of the multi-polar field of the motor-generator is wound with a series coil for starting purposes. The other portion of the fields, are wound with shunt and compensating coils, for generating and regulating purposes. The brushes are so connected, that the entire number is used for starting, whereas but three are used for generating.

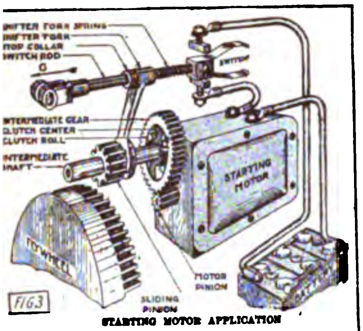
The storage battery is provided in some cases with two, and in some cases three, terminal posts. When two terminals are provided, a 14 volt lamp must be used. When three posts are provided, seven volt lamps are used.

The number of cells of battery are cut down from 12 to 6, giving 12 volts instead of 24.

CHART NO. 172—The U. S. L. (U. S. Light & Heat Corporation) **Electric System.** See also fig. page 347 for construction of generator.

Note—The U. S. L. Co., Niagara Falls, N. Y. are now employing a different principle This is shown as a matt of information.

Gray and Davis Motor-Generator.



STARTING MOTOR APPLICATION

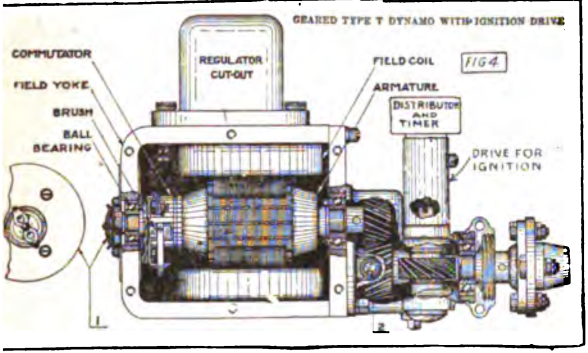
The starting motor is a separate unit, and is constructed for fly wheel drive, or crank shaft drive. Fig. 3 illustrates the fly wheel drive principle.

The starting motor switch is also shown—the action of which is clear in the illustration. **The battery** is a 6 volt battery.

The dynamo is a separate unit: compound-wound instrument driven by the engine. The driving power is transmitted by chains or gears, according to the installation.

The dynamo (figs. 4, 1 and 2) has two principal parts: The "field," in which magnetism is induced, is stationary. The "armature," in which electrical current is generated, rotates.

The dynamo has the characteristics of a compound-wound machine; that is, the field strength, or magnetism automatically increases as additional work or load (lamp load) is applied, and vice versa. But it is of the shunt wound type, and is thus classified; because its field windings are connected in shunt with, or across the armature.



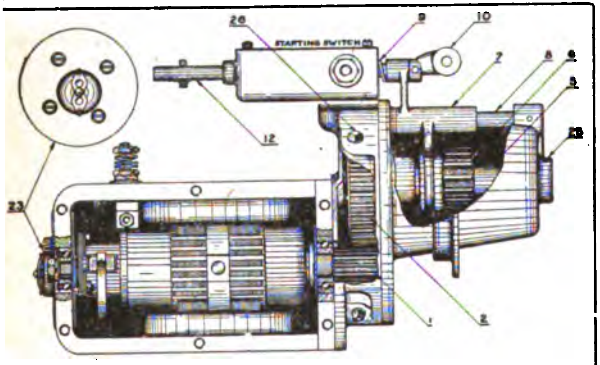


Fig. 1 SECTIONAL VIEW, Y MOTOR, ENCLOSED FLY-WHEEL TYPE

22 Oiler
25 Oil hole
26 Oil plug
1 Motor pinion
2 Intermediate gear
5 Intermediate shaft
6 Sliding pinion
7 Shifter fork
8 Shifter rod
9 Shifter fork spring
10 Clevis
12 Switch rod

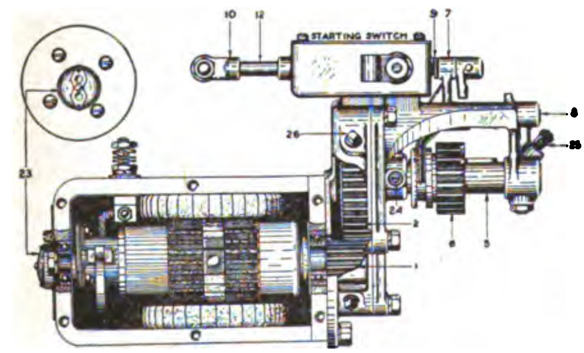


Fig. 2. SECTIONAL VIEW, Y MOTOR, OPEN FLY WHEEL TYPE

23 Oiler
24 Oiler
25 Oiler
26 Oil plug
1 Motor pinion
2 Intermediate gear
5 Intermediate shaft
6 Sliding pinion
7 Shifter fork
8 Shifter rod
10 Clevis
12 Switch rod

Reference to Wiring Diagrams.

Chart 174, shows the shunt field winding in parallel; one side connected to the positive dynamo brush; the other passes through the regulator points and is connected to the negative dynamo brush.

Type "T, G & D" dynamo is rated at 6½ volts, 10 amperes, 1,000 r. p. m.; type "S" dynamo is rated at 6½ volts, 10 amperes, 650 r. p. m.

The dynamo is connected to the engine by chain or gears, so that it will rotate at rated speed when car speed is 10 miles per hour, at which speed it should deliver current.

The Regulator and Cutout.

The regulator and cutout performs two duties: One to "regulate" the dynamo for uniform output. The other to connect the dynamo into the system only when sufficient to charge battery and to disconnect dynamo from the system to prevent battery discharging through dynamo.

The shunt winding, series winding, cutout points, regulator points and field resistance, are shown in wiring diagrams.

The shunt winding is permanently connected across the dynamo armature. It attracts the cutout armature, thereby closing the cutout points.

The series winding, when the cutout points are closed assists the shunt winding in holding cutout points firmly together.

The cutout points, when closed, connect dynamo into the system.

The regulator points, when closed, short circuit or shunt the field resistance, and when drawn apart, insert the field resistance into the field circuit.

The field resistance retards the flow of current in the field.

When dynamo is at rest, cutout points are open and regulator points closed.

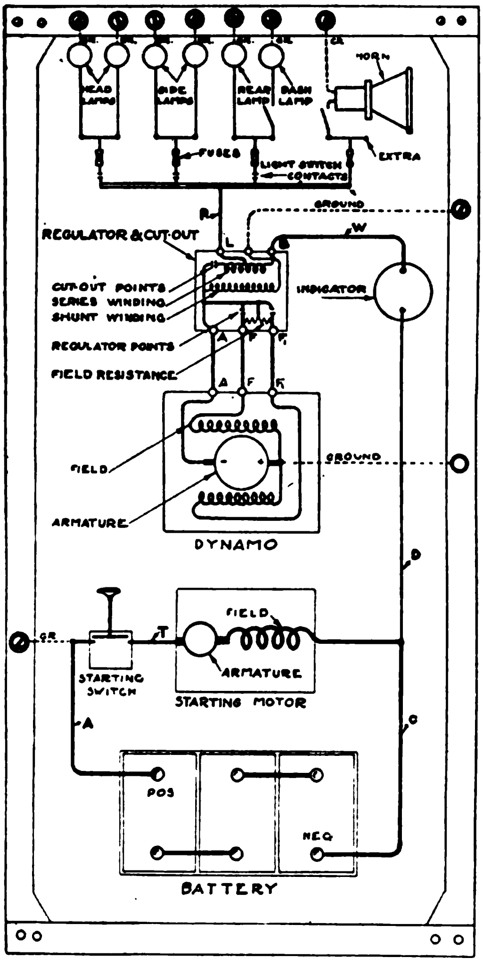
As dynamo first speeds up the regulator points remain closed. Thus, the field resistance is short circuited, permitting the dynamo to build up under full field strength. When the proper voltage is reached the points open, permitting current to flow through the series winding to the system.

As the dynamo speed increases beyond that necessary for full output the pull of the shunt winding attracts the regulator armatures. This reduces the pressure at the regulator points and inserts a resistance into the field circuit, which prevents further increase of output. The varying of the pressure at the points, which allows the resistance to be put into the circuit, is intermittent. The frequency is in proportion to the speed variation.

When lamps are turned on the frequency at the regulator points is reduced and the dynamo output is increased, giving the dynamo compound-wound characteristics. See A, chart 168, showing resistance in field circuit which gives an idea of the regulator.

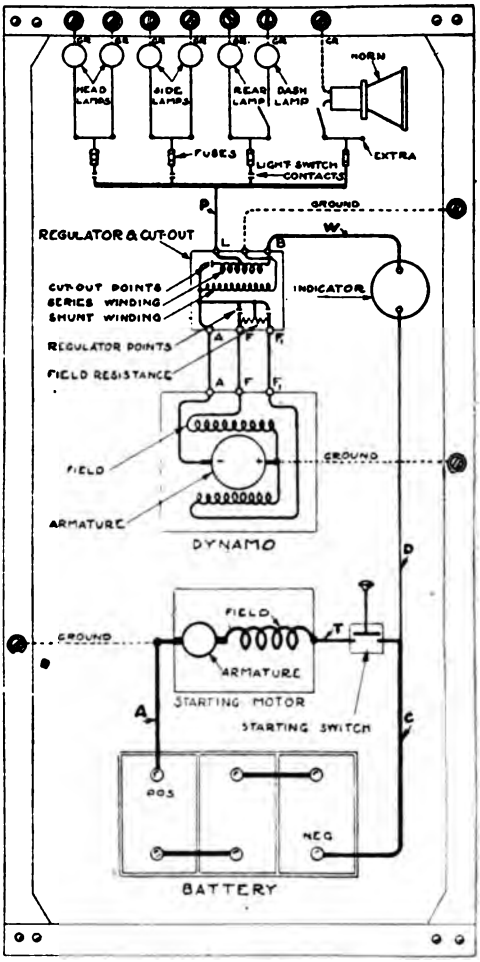
Ignition; is similar to Delco and other systems of this description. Note provision is made for driving timer and distributor on generator shaft (fig. 4).

ART NO. 173—One of Gray and Davis' Starting Motor and Generator. Fly Wheel Application of Starting Motor.



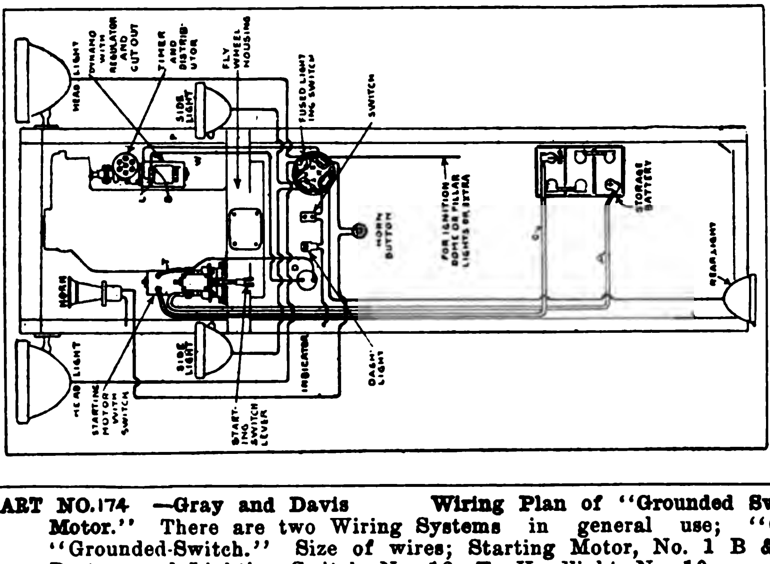
"Grounded Switch," system

Cable (A), instead of connecting directly to the starting switch, connects to frame of car. The car frame carries the current to the grounded terminal of starting switch.



"Grounded Motor" system

Cable (A), instead of connecting directly to the starting motor, connects to the frame of car. The car frame carries the current to the grounded terminal of starting motor.



To trace motor circuit, "grounded switch" circuit is traced from positive connection of battery through cable (A), starting switch, cable (T) starting motor and cable (C), to battery (NEG) terminal.

The "Grounded motor" circuit is traced; positive terminal, cable (A) to starting motor, cable (T), starting switch and cable (C), to battery (NEG) terminal.

CHART NO. 174 —**Gray and Davis** **Wiring Plan of "Grounded Switch" and "Grounde Motor."** There are two Wiring Systems in general use; "Grounded-Motor" an "Grounded-Switch." Size of wires; Starting Motor, No. 1 B & S gauge; Dynamo t Battery and Lighting Switch, No. 12; To Headlight, No. 10. —**see chart 173.**

INSTRUCTION No. 28.

*A STUDY OF LEADING ELECTRIC STARTING AND GENERATING SYSTEMS: Chalmers, Overland, Hupmobile, Marmon, Franklin, Locomobile, Saxon, Chevrolet, Maxwell, Mitchell, Studebaker, Dodge, Reo, Haynes; as Examples.

Pointers for Studying this Instruction.

The fundamental principle of the starting and generating systems have been treated in the preceding instructions. If the reader will master the principles as laid out in the foregoing matter it will not be a difficult matter to understand any and all systems, because each system embodies one or more of the principles explained. Although the methods of operation or construction may vary, the purpose remains the same.

We will devote this instruction to diagrams of the leading electric systems. With information gained from the preceding "**ignition**," "**electric starting**" and "**generator**" instructions, the reader ought to easily understand the various systems from these diagrams.

The Delco electric system will be treated under a separate instruction, also care of electric systems, wiring of electric systems troubles and tests.

‡**Electrical symbols**: before studying the different diagrams, learn the electrical symbols as illustrated on this page. For instance, the sign which denotes a "**ground**," "storage battery" or where "wires connect" or "pass over each other." They will be used quite freely in these instructions, as well as many of the other signs.

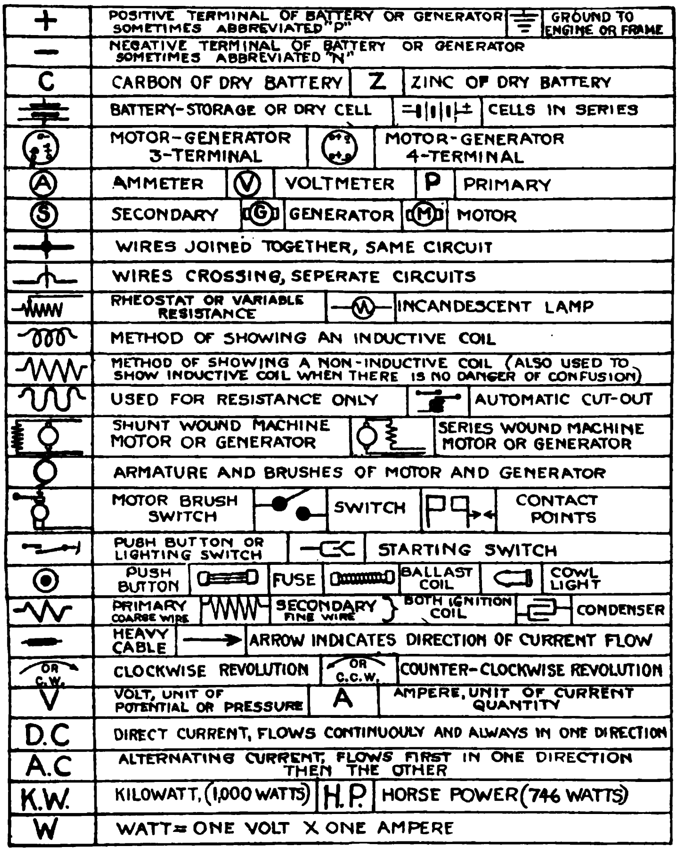
It is also advisable to refer to chart 181D, for the address of the leading manufacturers of electric systems and if the explanations are not clear, their catalogs will no doubt be of assistance.

Wiring principles: although this subject is treated under "wiring of electric starting and generating systems" it is well to know that there are two wiring principles; "single wire" and "two wire" systems.

The "**single wire**" system is where one insulated wire is used and the frame of car is used for the return circuit. This system is used most, as it will be noted in diagrams following.

The "**two wire**" system is where there is no ground to the frame, but two insulated wires are used.

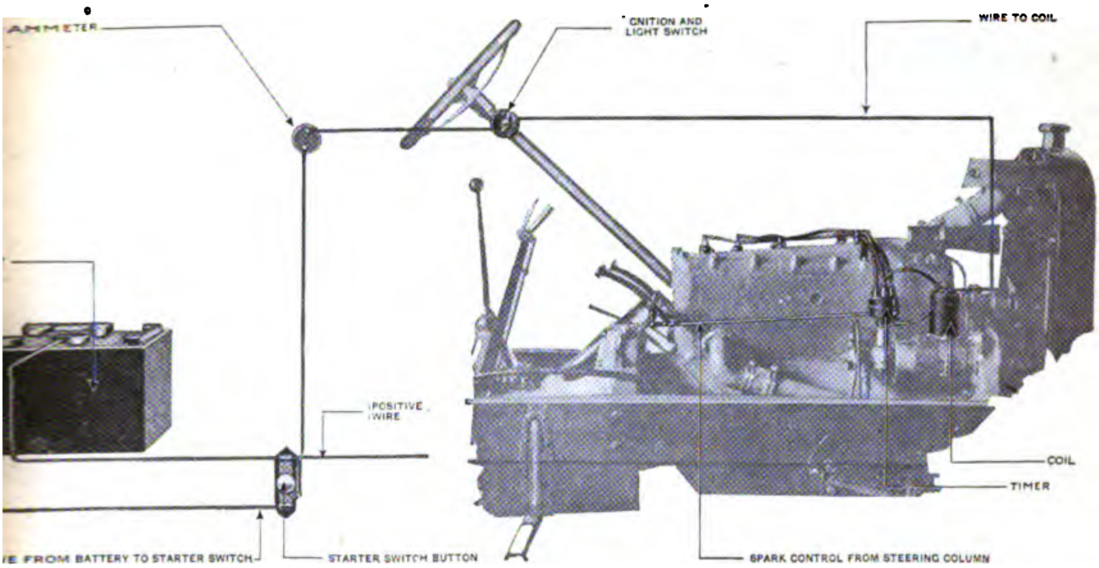
Another point to remember in studying the different electric systems: note the starting, generating, and ignition systems, are not always of one manufacturers' product. For instance, the Studebaker uses the Remy ignition and generator, and a Wagner starter. The King uses a Ward-Leonard starter and generator, and the Atwater-Kent ignition.


+
POSITIVE TERMINAL OF BATTERY OR GENERATOR SOMETIMES ABBREVIATED "P"
GROUND TO ENGINE OR FRAME
—
NEGATIVE TERMINAL OF BATTERY OR GENERATOR SOMETIMES ABBREVIATED "N"
C
CARBON OF DRY BATTERY
Z
ZINC OF DRY BATTERY
BATTERY-STORAGE OR DRY CELL
CELLS IN SERIES
MOTOR-GENERATOR 3-TERMINAL
MOTOR-GENERATOR 4-TERMINAL
A
AMMETER
V
VOLTMETER
P
PRIMARY
S
SECONDARY
G
GENERATOR
M
MOTOR
WIRES JOINED TOGETHER, SAME CIRCUIT
WIRES CROSSING, SEPERATE CIRCUITS
RHEOSTAT OR VARIABLE RESISTANCE
INCANDESCENT LAMP
METHOD OF SHOWING AN INDUCTIVE COIL
METHOD OF SHOWING A NON-INDUCTIVE COIL (ALSO USED TO SHOW INDUCTIVE COIL WHEN THERE IS NO DANGER OF CONFUSION)
USED FOR RESISTANCE ONLY
AUTOMATIC CUT-OUT
SHUNT WOUND MACHINE MOTOR OR GENERATOR
SERIES WOUND MACHINE MOTOR OR GENERATOR
ARMATURE AND BRUSHES OF MOTOR AND GENERATOR
MOTOR BRUSH SWITCH
SWITCH
CONTACT POINTS
PUSH BUTTON OR LIGHTING SWITCH
STARTING SWITCH
PUSH BUTTON
FUSE
BALLAST COIL
COWL LIGHT
PRIMARY COARSE WIRE
SECONDARY FINE WIRE
BOTH IGNITION COIL
CONDENSER
HEAVY CABLE
ARROW INDICATES DIRECTION OF CURRENT FLOW
OR C.W.
CLOCKWISE REVOLUTION
OR C.C.W.
COUNTER-CLOCKWISE REVOLUTION
V
VOLT, UNIT OF POTENTIAL OR PRESSURE
A
AMPERE, UNIT OF CURRENT QUANTITY
D.C
DIRECT CURRENT, FLOWS CONTINUOULY AND ALWAYS IN ONE DIRECTION
A.C
ALTERNATING CURRENT, FLOWS FIRST IN ONE DIRECTION THEN THE OTHER
K.W.
KILOWATT, (1,000 WATTS)
H.P
HORSE POWER (746 WATTS)
W
WATT = ONE VOLT X ONE AMPERE

---

*See charts 229 to 232 for "**Specifications of Leading Cars**," which will give the make of starter, generator, ignition, carburetor, etc., used on all leading cars. See chart 228 for "Standard Adjustments," giving the system of ignition, adjustments, etc. See instruction No. 34, "**Operating Cars**," for lever movements, for gear shift, and control systems of different leading cars. See chart 197 for "**Lamp Voltages.**" See index, "**Removing Battery.**" *See instruction No. 24 and chart 228 for "**Ignition Timing.**"

‡A storage battery is indicated by a long line as positive plate, and a short black line as negative plate. One pair of lines represent a cell, for instance, note symbol to designate a 3 cell battery—at lower left corner of fig. 1, page 391.

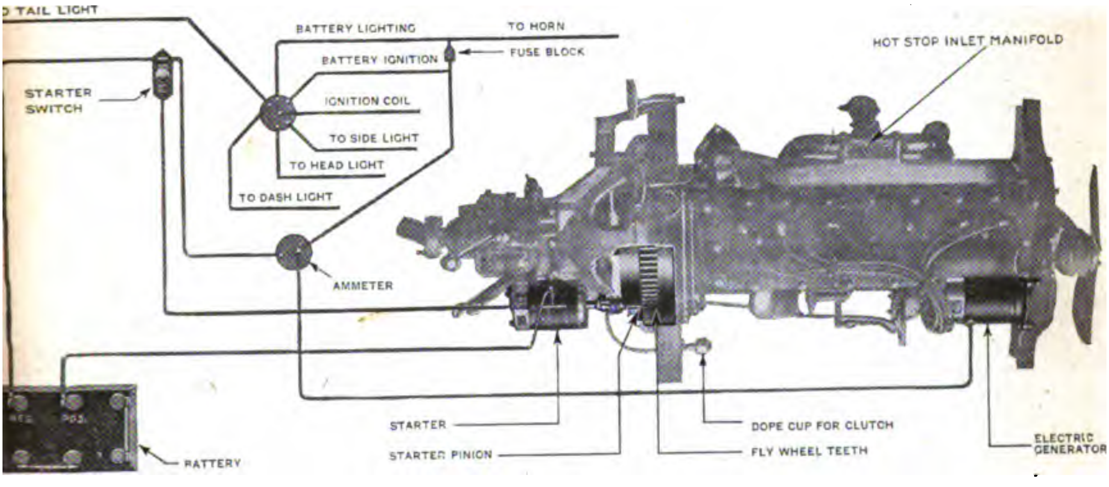

AMMETER
IGNITION AND LIGHT SWITCH
WIRE TO COIL
POSITIVE WIRE
COIL
TIMER
E FROM BATTERY TO STARTER SWITCH
STARTER SWITCH BUTTON
SPARK CONTROL FROM STEERING COLUMN

By referring to the "Specifications of Leading Cars," charts 229 to 234, it will be noted that the Chalmers use a Remy ignition system and a Westinghouse starter and generator.

The ignition system: The timer and distributor are located on the generator and driven by spiral gears off the generator drive shaft. The connections are shown in diagram. The firing order is 1, 4, 2, 6, 3, 5. The timing contact points should be kept adjusted to .015 to .020 inches. Spark plug opening should be .025 inches.

Setting of timer. Place piston in No. 1 cylinder 1$\frac{5}{16}$" after top dead center, between power and compression stroke. Then the timer should be slowly and carefully turned backward (contrary to the direction of normal rotation) until the interrupter points just separate. At this point connect up levers so that with fully retarded spark lever on the steering gear quadrant, this interruption should have just taken place. The cam on timer is a hexagon six point cam. It is a taper fit on shaft and locked in position by a small nut screwed on the shaft over top of cam. Distributor should just be making connection with spark plug in cylinder number 1.

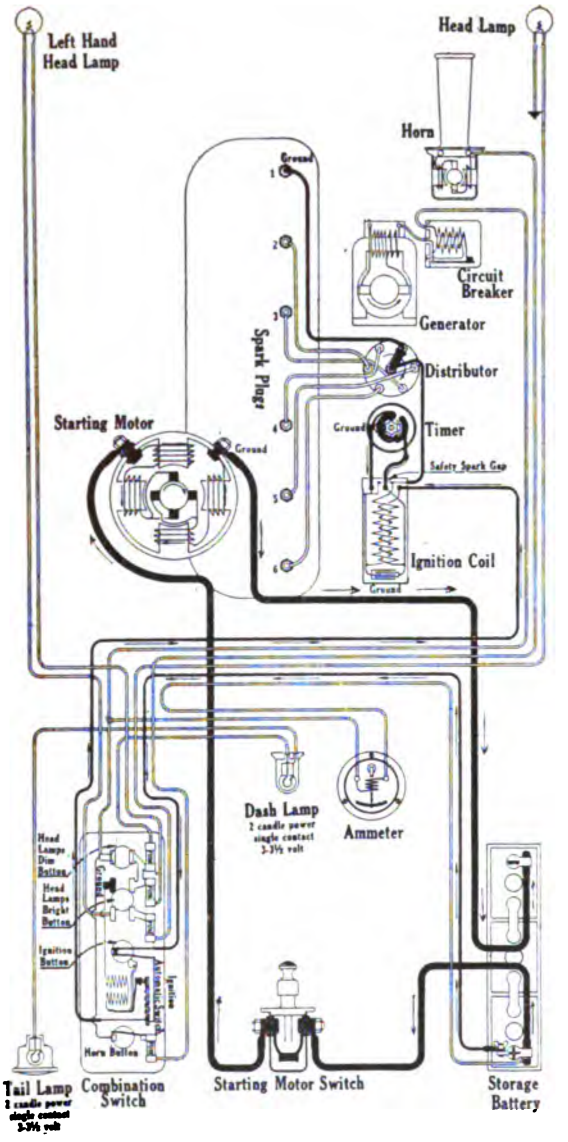
All upper dead centers are marked on rim of fly wheel thus—D. C. 1 & 6, D. C. 4 & 3 or D. C. 2 & 5, as the case may be.



The electric starting motor is the Westinghouse, with the automatic gear shift, of the Bendix principle, as explained in charts 160 and 161A.

The generator is also of the Westinghouse make and is located separate from the starting motor. This system would be termed a "two-unit" system.

CHART NO. 175—Chalmers Model 35-C Remy Ignition and Westinghouse Starter and Generator.
See page 318 for "Chalmers 35" Ignition Timing and Valve Timing. The older model "six-30" Chalmers used the same electric system but parts were placed in a different position.



Overland Electric System.

Starting circuit is from positive battery terminal through starting motor switch to insulated starting motor terminal, through two field coils to brushes, through armature to brushes, through field coils to grounded starting motor terminal, through cable to negative battery terminal.

When "ignition" button (2, fig. 12, page 359) is pushed in, circuit is from the ground on the starting motor through battery to positive terminal, through switch to thermostatic spring on automatic switch to post marked "C" on coil, through primary or low tension winding from post marked "T" on coil to stationary contact point on Timer, through contact points and Timer arm to ground.

Induced **secondary current circuit** is from the ground on the ignition coil, through the high tension winding to the center terminal on distributor cover, through distributor arm to spark plug wire terminal through spark plug points to ground.

If engine is left standing with timer points in contact the steady flow of current through the thermostatic spring of the automatic ignition switch makes contact with vibrator point, and the action of the vibrator throws the Ignition button out. (see page 254.)

Battery "charging" circuit; ammeter will show "charge" from 1 to 15 amperes, varying with speed. Battery grounded on starting motor. Generator shunt field winding circuit is from generator brush, through shunt field windings to generator brush.

When circuit breaker points are open; circuit is from generator ground through armature, through series field coils to circuit breaker through circuit breaker shunt to ground. **Shunt in circuit breaker closes points;** circuit is now from generator ground through armature, through series field winding to circuit breaker, through circuit breaker points, through circuit breaker series winding, through ammeter to positive battery terminal, through battery to ground on starting motor.

When charging, current through battery is from positive terminal to negative terminal. **When discharging,** current is from negative to positive terminal. When voltage produced by generator is less than battery voltage, the circuit breaker points open.

"Head lamps dim" and "horn" circuit. Ammeter will show discharge of three or four amperes. Negative battery terminal is grounded on starting motor.

Head lamps dim circuit is closed when lower button on combination switch is pulled out. Lower button, when pulled out, makes contact between first pair of contact springs and second button from bottom of combination switch; when pushed in makes contact between third pair of contact springs.

Circuit is from ground on starting motor through battery to positive terminal through ammeter to first pair of contact springs, then, (first) through fuse, through dash lamp, through tail lamp to ground; (second through fuse, through left head lamp, through third pair of contact springs in combination switch, through fuse, through right head lamp to ground. Head lamps are in series on six-volt circuit.

When top button on combination switch is pushed in, "Horn circuit" is closed, and circuit is from battery ground through battery, through ammeter, through horn switch, through fuse, through horn to ground.

"Head lamps bright" circuit; two lower buttons on combination switch pulled out. Lower button pulled out makes contact between first pair of contact springs, and second button from bottom of switch makes parallel contact between second left-hand and third left-hand contact springs, also from second right-hand to third right-hand contact springs.

Circuit is from battery ground on starting motor through battery, through ammeter, through first pair of contact springs; (first) through fuse, through dash lamp, through tail lamp to ground; (second) through fuse, through left-hand lamp, through third left-hand contact spring to second left-hand contact spring to ground; (third) to second right-hand contact spring to third right-hand contact spring through fuse, through right head lamp to ground.

Overland Models.

Model 90—Light 4 cylinder car, prices $985 to $1495.
Model 85—Four cylinder car, prices $930 and $915; discontinued.
Model 89 Touring—Six cylinder car, price $1625.
Willys Six—Six cylinder car, prices $1365 to $2045; discontinued.
Willys-Knight—Four cylinder car, prices $1725 to $2750.
Willys-Knight—Eight cylinder car, prices $2750 to $3500.

CHART NO. 175A—Overland Electric Systems—All Overland cars use Electric Auto-Lite Electric Generator and Starter. Connecticut Ignition (page 254). See index for Overland Control System and page 183 for Overland Carburetor—and pages 497 and 49 for Gear Shift Control.

Overland electric system continued—

The Overland starting motor is an Auto-Lite make, with a Bendix drive. 6 volt. Located at rear of engine—right hand side, and acts directly on fly wheel gear.

To start engine—place spark and throttle levers as shown in fig. 10. Put ignition switch "on"—as shown on switch box on steering post fig. 12. Press down starter switch (by a toe button) located in front of driver's seat. This makes necessary connection with storage battery, and throws the gear on starter shaft, in mesh with gear on fly wheel. See Bendix description in charts 161A and 160.

The generator is driven by a silent chain from the engine crankshaft.

Regulation; the output of the generator is controlled by the windings of the machine itself, doing away with mechanical governors and clutches. This electrical control, is absolutely automatic, consisting of a reversed series winding which cuts down current production at the proper point by the simple method of weakening the strength of the field.

The generator begins to produce current at a car speed of about 7½ miles per hour. and the production climbs until, at about 20 miles per hour, the generator is producing its maximum output of 14 amperes. At this point the reversed series coil holds the output, no matter how fast you may drive. Ten amperes, or an abundance of current for both lighting and charging, is produced at about 15 miles per hour.

The circuit breaker; its function is to disconnect the current-producing generator from the storage battery when the engine is standing still or runs below the speed at which the generator will produce current of charging voltage (see fig. 13).

If the circuit breaker is removed the car must not be operated until a short piece of bare copper wire is securely connected from the wire terminal post of the generator to one of the brass screws on the nameplate and the ends of the wires leading to the cutout or circuit breaker must be taped to protect them from touching each other or any metal part of the car.

The ammeter; its purpose is to show whether the system is working properly or not. When the generator is running and sending current to the storage battery, the ammeter hand will point to the left of zero, or at "charge." When the lights are burning and the car is at rest, the indicator hand will point to the right of zero, or at "discharge," indicating the rate at which current is going out of the storage battery. When the engine is running and the lamps burning and the ammeter hand stands at zero, it indicates that the generator is producing exactly the same amount of current that the lamps are consuming.

Switch box on steering column (see fig. 12): There are four push button switches on all Overland cars, as follows: 1st, horn; 2nd, ignition; 3rd, **head lights;** 4th, dim lights.

The rear and instrument lights are connected with 3 and 4. The Overland formerly used 5 switches, that was for a solenoid connection for starting, but late models use but 4 switches.

The lighting and starting wiring systems are independent of each other, and are easily recognized. by the fact that the starter wiring is of heavy round single conductor cable, while the lighting wiring is of much smaller single strand armored cable. All wiring is specially insulated to withstand mechanical chafing and vibration and the unavoidable exposure to oil, dirt and water.

The lamps receive their current either direct from the generator, or from the storage battery, depending upon the speed of the car. As the system is what is known as a "grounded" system, only one wire leads to each lamp, the return path of the current being through the frame of the car (see page 434 for size and style lamps used).

To tighten generator brushes—see page 409 "generator does not generate full current." The Chevrolet also uses the Auto-Lite generator—see page 364.

To raise rate on Auto-Lite generator of model 85 Overland, remove the small brass cover plate from the side of the generator, when it will be noticed that the brush holders are fastened to a ring in the end of the generator. Loosen the screws which hold the ring in place from the outside and turn the ring in the direction which the armature rotates when the engine is running. By this means the output can be raised to about 14 amp. See also page 364 and 409.

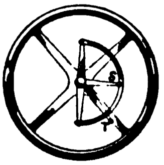


Fig. 10. Position for Spark and Throttle Levers when cranking with Electric Starter.

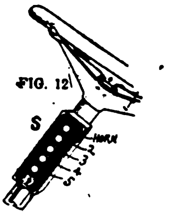


FIG. 12

Fig. 12. The Overland switch box on steering post. Levers move up, to advance spark and open throttle.

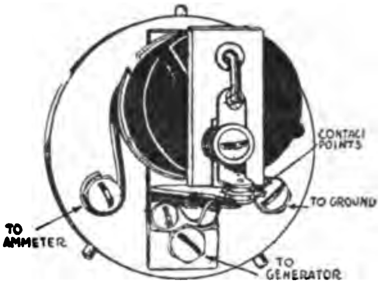


Fig. 13. Auto-Lite cutout as used on the Overland and other Auto-Lite systems.

Should the battery or the generator be disconnected for any reason, do not operate engine until they are again connected. Or, in case such operation is found necessary, be sure to connect a short piece of bare copper wire, from the terminal post of generator, to brass screw in name plate.

Ignition: The Connecticut make is used. See page 254, for method of assembling and taking apart, etc. The breaker points should be set .025 inch apart. The spark plug gaps should be .020".

***Timing Overland ignition (85B):** The break in the timer should occur (with the spark lever fully retarded), at the instant the flywheel is 1½ inch past the upper dead center mark of the cylinder in which the spark occurs.

To properly time the device, proceed as follows: turn the engine over slowly by hand until the mark on the flywheel 1 and 4 UP is 1¼ inch past the punched indicator marks on the rear end of the cylinder block, **just after the completion of the compression stroke of the engine.**

**To determine that the piston is in this position, watch the operation of the intake valve of the No. 1 cylinder, which may be most easily done by removing the spark plug in the cylinder head over the No. 1 cylinder. By putting a screw driver through the opening, and allowing it to rest on the valve head, at the time the engine is being turned over, the action of the valve can be readily determined.

After it has reached the bottom of its travel, turn the engine over approximately one-half turn until the 1 and 4 UP mark on the flywheel is in the position given above.

Then so mesh the timing gears with the timer drive gear, that the points in the breaker box just start to separate, and the rotating unit of the distributor is in line with the wire terminal which leads to the No. 1 cylinder.

The firing order is 1, 3, 4, 2. The wires are then connected from distributor to spark plugs, in their proper order.

Silent chain adjustment of the Overland, meshing gears, etc. is explained on page 113 and 112.

CHART NO. 175AA—Overland Electric System—continued.

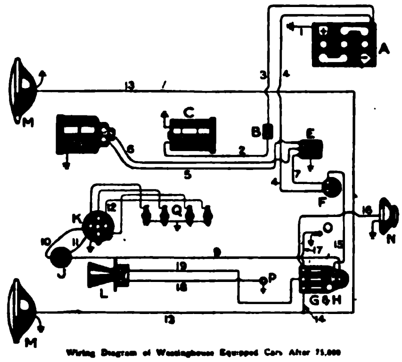
*Timing "Country Club" model; spark lever is retarded. Break of points on timer should occur when de center mark on fly wheel is 1¾ in. past mark upon rear end of engine block.

**See also page 320 "finding end of compression stroke." See pages 497 and 49 Overland gear shift.

Hupmobile Series "N"—1916-17 Electric System.

The Hupmobile formerly used a Bijur starter and generator. The system now used is a Westinghouse starter and generator and the Atwater-Kent Ignition.

Westinghouse generator—driven by chain front end right side. Charges battery at 8 miles per hour, at which point the cut-out connects with battery. At 20 miles per hour, generator reaches its maximum. Charging rate 14 to 18 amperes if battery is low, and 6 to 9 amperes if battery is well charged.



Wiring Diagram of Westinghouse Equipped Cars After 75,000

A—Storage Battery
B—Starting Switch
C—Starting Motor
D—Generator
E—Voltage Regulator
F—Ammeter
G—Ignition Switch
H—Lighting Switch
J—Spark Coil
K—Atwater-Kent Ignition
L—Horn
M—Head Lamps
N—Tail Lamp
O—Instrument Lamp
P—Horn Push Button
Q—Spark Plugs

The regulator performs two functions. It acts as a cutout, which connects and disconnects generator from the battery at a certain predetermined speed. It also acts as an automatic voltage regulator which, after the cutout has made connection between the generator and battery, automatically keeps the generator voltage below a certain fixed value, and thereby controls the output of the generator.

Wiring: There are two wires leading from the generator to the regulator. The larger of these two wires connects the generator terminal nearest to the engine with the regulator terminal, which is at the extreme right as viewed from the driver's seat. The other wire connects the generator terminal nearest the car frame with the middle terminal on the regulator. (See illustration above.)

To adjust generator chain tension proceed as follows: slightly loosen the three nuts holding the generator to the crank case, remove the shield over the front of the generator, then with the lower bolt as pivot, the generator can be swung to either side until the proper tension is obtained.

The chain can only operate in one direction. Arrows stamped on each link show the direction in which the chain should run. **The proper chain tension** or adjustment is when a very slight motion can be felt in the chain.

Starting motor is located on right side of engine and drives through a gear on the flywheel operated by a foot pedal. **Starter pedal** is located to right of foot accelerator pedal.

Ignition—Atwater-Kent (see page 248). **Firing order** 1, 2, 4, 3.

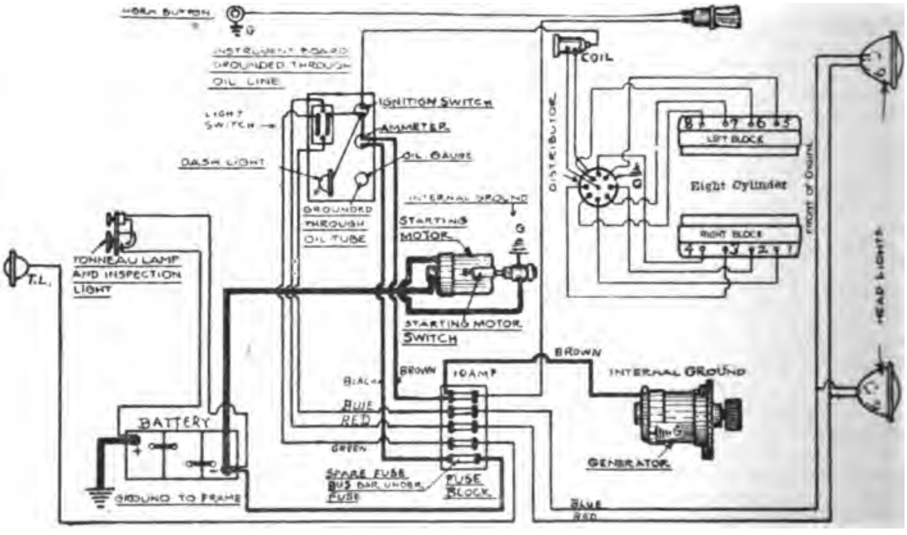
Setting the ignition: Set the hand spark lever in a horizontal or mid position on the sector, and loosen the two nuts on the control rod at either side of the small swivel block at the igniter.

The piston in No. 1 cylinder should be raised to top dead center, which should be at a time when the mark "1 and 4 OL" on the flywheel registers with the dead center, which can be ascertained by removing the flywheel cover. Turn on past dead center about two inches. Then the distributor unit should be turned so that the lug, to which the swivel connects, points directly away from the carburetor and then carefully turn back about 1/6 of a turn contrary to the direction of normal rotation of the distributor shaft, until a click is heard; then clamp the adjustment in place.

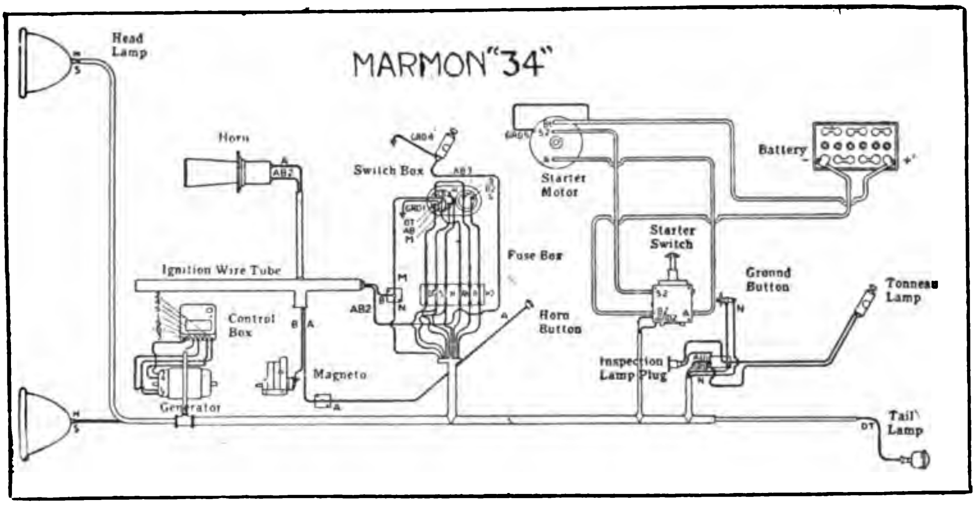
If the distributor unit has been properly installed, the metal edge of the distributor block, should be pointing toward the radiator.

King Eight-Cylinder Model "EE & F" Electric System.

Wiring, single wire, grounded return; **Lamps**, single contact. All are 6-8 volt. Head lights are 18 c. p. and 4 c. p. Instrument and tail light 2 c. p. **Fuse**, 10 amp.; **Generator**, Bijur constant current type, page 925; **Starting motor**, Bijur with Bendix drive, page 331; **Ignition**, Atwater-Kent, type "CC" closed circuit per page 249. **Ignition timing**, place No. 1 piston on top, place spark lever within ⅛ inch of full retard and time per page 250, except timer should have a ⅞ in. or 1 in. movement, automatic advance not used. **Firing order**, 1, 8, 3, 6, 4, 5, 2, 7.



HART NO. 175B—Hupmobile Electric System. King Model "EE and F" Electric System.



Bosch starting, generator and ignition system. Three unit type. Ignition: Bosch DU6, independent magneto, driven from the generator shaft, by means of a flexible coupling. A grounded, "one wire" system is used.

Ignition timing; the magneto should be so timed, that with a fully retarded spark, the interrupter platinum points will just begin to separate. when the line marked "top center" on the flywheel has still one inch to go before passing under the flywheel pointer. On the magneto coupling. there is an adjustment by which the magneto timing may be advanced or retarded, in its fixed relation to the engine piston, as desired. For firing order, see "Standard Adjustments of Leading Cars," chart 228.

Starting motor—Is series wound with a displacement type armature, called the "automatic electro magnetic gear shift" type. It is located on the right hand side of engine. See chart No. 161.

The Bosch dynamo, type "DSR-3," is a shunt wound machine, having an iron ballast coil working in parallel with a bucking field coil, (see illustration B, chart 163,) these serving to keep the dynamo output within the proper limits.

At low dynamo speeds the current on the line passes through the ballast, which, when cold, has a high conductivity.

At higher dynamo speeds, however, when the current output is liable to rise excessively, the ballast heats up, and its higher resistance forces a high proportion of line current through the bucking coil mounted on the field, thus reducing the dynamo output automatically, see fig. 2, chart 166.

The control box, is mounted above the generator, convenient for inspection. Incorporated in the control box are the automatic cut-out, the field fuse and the iron ballast coil. The automatic cut-out is provided for the purpose of automatically connecting the dynamo to the battery, when the dynamo voltage is at a value sufficient to cause the battery to charge, and automatically disconnecting the dynamo from the battery, when the dynamo voltage drops below that necessary for charging.

Voltage—The Bosch system here described, is of the 12 volt type, using Willard 6 cell storage battery.

Dynamo lubrication—Each oil cup should receive two or three drops of oil every 500 miles. Light machine oil and not cylinder oil should be used.

Trouble Finding.

Trouble finding: If the ammeter registers on the discharge side when all the lights are off, particularly when the engine is running; or if a heavy reading is noted on the discharge side when the lights are on and the engine is standing, either a ground or a short circuit is indicated. If with lights off and engine operating at normal speed, the ammeter shows zero and at the same time the proper battery discharge reading is obtained when the engine is stopped and the lights are on, the generator is not working.

If the lights are obtainable with the engine at a standstill proceed as follows: Inspect the main fuse in the control box; see whether battery is badly run down; loose or broken battery connections; loose, broken or disconnected wire between battery and the OB (marked on switch) terminal of the switch that is, either between the negative terminal of the battery and the B terminal of the control box and the OB terminal of the switch, or between the positive terminal of the battery and ground.

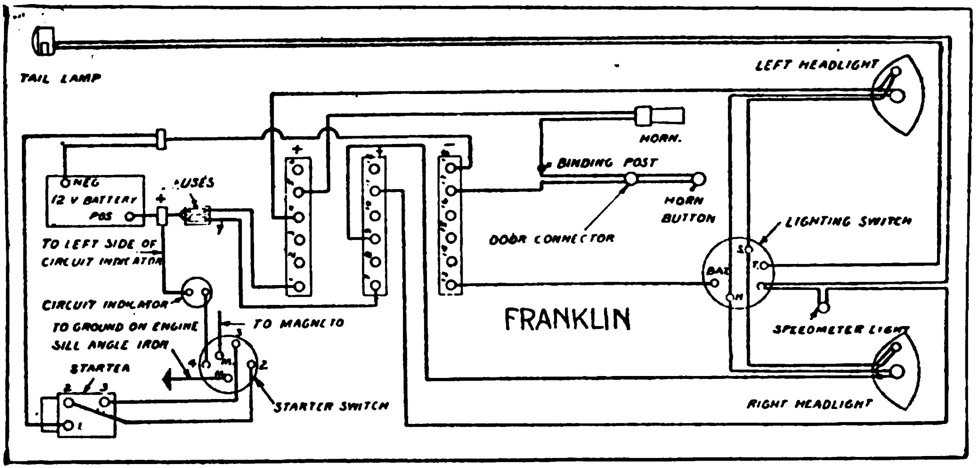
If the fuse is blown the trouble should be located by testing the various lamp circuits before a new fuse is put in.

If lights are obtainable only when the engine is running, it is likely that the battery has become disconnected. If this is so, the ammeter will show zero with all lights off instead of reading charge when the engine is running. Also when the lights are switched on with the engine running, the intensity of the lights will vary with the speed of the engine. The engine must not be operated under these conditions, as there is danger of burning out the windings of the generator.

If all lights are dim with the engine off, the trouble may be due to a weak battery; poor connection at the battery, or at some point in the circuit, between the battery and the terminal OB of the lighting switch; a deteriorated main fuse; a partial short circuit as mentioned above.

Battery polarity reversed: If, when making the installation or at any other time, the battery should be incorrectly connected to the system, the cut-out will vibrate rapidly; this must be remedied by interchanging the wires which connect to the battery terminals at the battery.

CHART NO. 176—Marmon "34:" Bosch Starting Motor, Generator and Ignition System.



Franklin Electric System.

The Dynsto starting and lighting system on the **Franklin,** is a combined generator and starting motor in one unit. The complete electrical system therefore, is of the two unit type. (Starter and generator form one unit and Atwater-Kent ignition the other.) The starter is driven by a silent chain.

This system requires neither a voltage regulator or a cut out, automatically changing from a motor to a dynamo as the engine speeds up. At high speeds, the connection between generator and battery is opened by the driver through a switch on the dash. The current is held to a maximum of 11 to 13 amperes at a speed of 16¼ miles per hour by a third brush regulator. The generator starts to charge the battery at a car speed of 7½ to 8½ miles an hour. Generator is charging battery when indicator shows "Charging."

Care: The commutator brushes, two in number, should be examined every 3000 miles, and replaced if necessary. The brushes can be reached by sliding cap from top of rear end of starter.

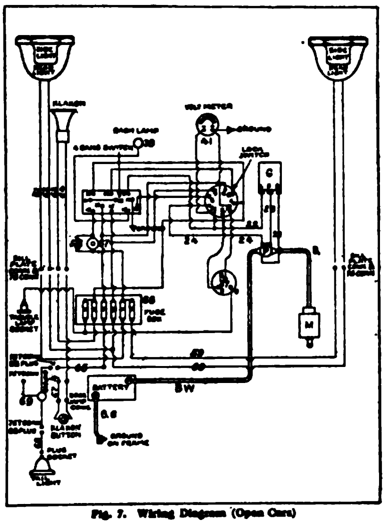


Fig. 7. Wiring Diagram (Open Cars)

BG—Battery ground wire (+).
BW—Battery lead wire. (—).
G—Generator.
M—Starting Motor.
P—Primary relay or cut-out switch.
4—Gang switch.
16—Tail-light bus.
19—Ground connection.
37—Ignition switch.
41—Volt meter.
57—Dimmer switch.

Ignition: The Atwater-Kent system of ignition used. is the K-2 type, with automatic spark advance (see chart 117). This system uses very little current and in case of a dead battery, it can be operated on dry cells. The breaker points should be set .010 inch apart.

Wiring: The lighting system is wired independent of the starting system. **The head and dimmer lamps are 14-volt** and are wired in parallel so that the burning out of one lamp will not affect any other. **The tail and dash lamps are 7-volt** and are wired in series so that if either one burns out, the other will not burn. The dash light is therefore a tell-tale for the tail light. The horn is a 14-volt one.

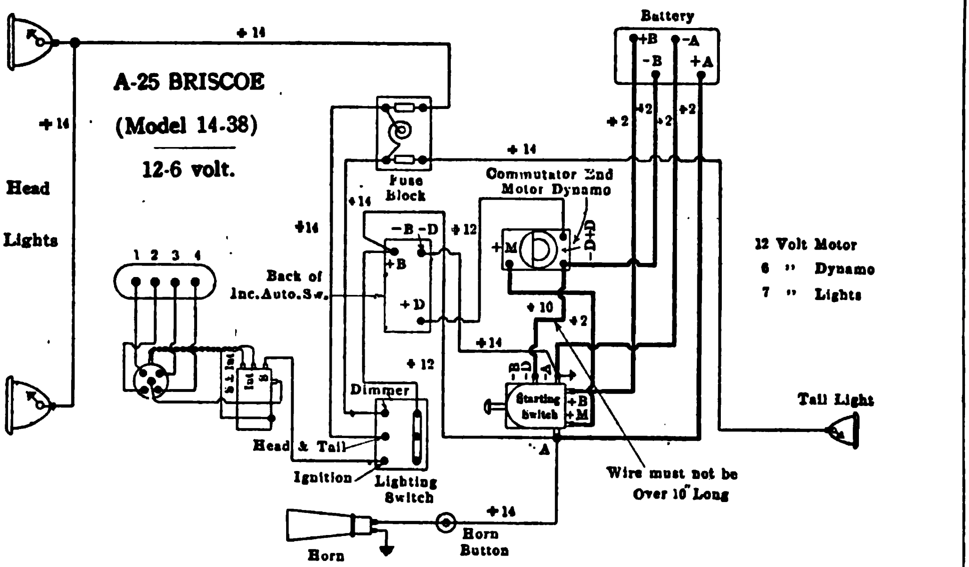
Locomobile Electric System.

Westinghouse generator and starting system. Three unit type. Generator is placed on right side. Regulation: by a differential winding of the field, and is magnetic—no moving parts. **Starter:** on left side of engine and works upon the flywheel ring gear from below. **Ignition:** separate Eisemann magneto—high tension dual system—similar to the Bosch, as explained in charts 134 to 136. **Firing order:** 1, 5, 3, 6, 2, 4. **Magneto setting:** with spark full advanced, spark occurs while piston is 7/16 inch from top (on the "48") and 5/16 inch from top on the model "38." **Battery and coil setting:** with spark lever retarded, spark will occur, after piston has just started down—this is to make hand-cranking safe.

Battery: 6-volt—used for starting, lighting, and ignition. **Wiring:** Single-wire, grounded return.—Positive terminal of battery (BG.) is grounded. Negative side (BW.) goes to primary relay or cut-out—switch (P). **Lighting:** current is taken through wire (21) from switch (P) to the terminal (B) of the generator (G.) passing through field winding of generator, and out at terminal (L) to lead (22) thence to terminal (1) of lock-switch.

Starting Motor: Wire (23) runs to magnetic coil in switch (P) from here lead (24) goes to terminal (9) on lock switch—out terminal (8) to terminal (20) on "gang dash-switch," then to ground via terminal (19.) When starting button is pressed,—current flows along wires (23 and 24), lock switch (P) closing switch and thus permitting current to flow through (B) to the starting motor magnetic switch. The magnetic pinion shift, is an electro-magnetic affair, which automatically throws the armature shaft with its pinion, in mesh with fly-wheel gear.

CHART NO. 177—Franklin: The Dyneto Starting Motor and Generator and Atwater-Kent Ignition. The Locomobile Model "38" & "48:" Eisemann Magneto Ignition and Westinghouse Starter and Dynamo. (see pages 500 and 497—Loco gear shift and spark control)



Splitdorf-Apelco.

The Splitdorf-Apelco starting and lighting, system as a single unit, consists of a motor-generator, indicating automatic switch and starting switch, together with a 12-volt storage battery.

Generator: By connecting the motor dynamo across the terminals of the battery, through the starting switch, the motor-dynamo acts as a motor, spinning the engine until it picks up on its own power. The motor-dynamo is then driven by the engine as a generator, furnishing current for charging the battery.

Acting as a motor, the unit has sufficient power to spin the engine at a good rate of speed. As a generator, it has capacity to keep the battery fully charged insuring ample current for starting, lights, ignition, horn, etc.

The armature of the machine has but one set of windings, one commutator and one set of brushes. No gears or clutches are employed in the construction of the motor-dynamo, the armature being the only revolving part. Sprockets and silent chain are used for driving the starting and lighting unit, no additional reduction being necessary than that secured through the sprockets.

The current output of the dynamo is controlled by means of the special field windings. This **inherent** regulation feature makes it impossible to charge the battery at too high a rate, and at the same time makes the use of any regulators unnecessary.

The indicating automatic switch, is mounted in the circuit between dynamo and battery. Its function is to make connection between these two units when the voltage of the dynamo exceeds that of the battery—as well as break connection when the battery voltage exceeds that of the dynamo. In other words, the switch automatically closes when the dynamo is being driven at sufficient speed to charge the battery allowing current to flow from the dynamo into the storage battery. When the dynamo is not running at sufficient speed to charge the battery, however, or is stopped, the switch automatically opens, preventing a discharge of current from the battery back through the dynamo.

The Indicating Automatic Switch is equipped with an Indicating Dial which is mounted on the dash and shows at a glance whether or not the battery is being charged. When current is flowing into the battery the words "Charge On" show on the dial and when the battery is not being charged the words "Charge Off" appear.

The Starting Switch is one built especially for use with this system. Its design is such as to make arcing of the contact impossible.

A 12-6 volt Storage Battery is used in connection with the Splitdorf-Apelco starting and lighting system for motor cars. The battery is divided into two individual 6-volt units which are enclosed in one case.

At the time of starting, when the starting switch is pressed down, the two 6-volt units of the battery are then connected in series through the switch, furnishing 12-volt current to the motor-dynamo.

This, however, does not affect the voltage to the lamps, as 6-volt current is supplied for lighting and ignition at all times. As soon as the starting switch is released, however, the two battery units are connected in parallel and charged as a 6-volt-battery.

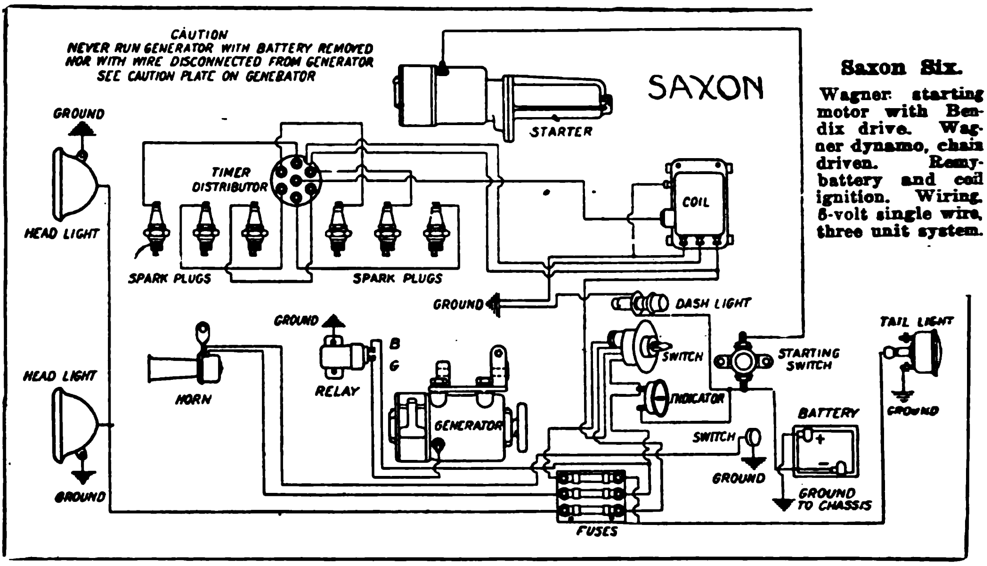
The use of 12 volts for starting, insures sufficient power to spin the engine under normal conditions, as well as cuts down the current drawn from the battery. At the same time, 6 volts for charging makes it posible for the generator to begin charging at very low car speeds, as well as makes the use of 7-volt bulbs possible for the various lamps on the car.

General circuit: The current flows from + D on generator to + D on indicating switch, through the winding in the coil, coming out at + B, then to + A on starting switch, where it divides, one side leading to + A on battery through battery to —A on starting switch. The other half of the current flows through jumper in the switch to + B on starting switch, through to + B in battery through battery to —D on generator thence to —B—D on starting switch —B-D are the common return points of the current on starting switch, from there to —D on generator.

Starting switch: When the switch is depressed the current flows from the battery at + A to + A on starting switch, through switch to + M on switch. then to + M on motor dynamo, through motor-dynamo to —B—D on starting switch, then to —B on battery, through battery to + B on battery then to + B in starting switch, through switch to —A on switch to —A on battery, through battery, to + A completing the circuit.

If battery is removed: connect a wire across posts —D and + D of motor-generator.

HART NO. 178—Splitdorf-Apelco Electric System as an Example of a 12 volt Motor-Generator—as formerly used on Briscoe. The Ignition is Connecticut.



Saxon Six.

Wagner starting motor with Bendix drive. Wagner dynamo, chain driven. Remy battery and coil ignition. Wiring 6-volt single wire, three unit system.

To set timer on Saxon, crank engine until piston No. 1 has passed its uppermost position, on compression stroke one inch on the fly wheel. This position can be determined by dead center mark (DC) on fly wheel. Move to position one inch past the fly wheel pointer. No. 1 post on timer cap must now be in position to make contact with wiper. Rotate body of timer until contact breaker opens. Now connect timer to spark control lever. Set above with spark lever full retard. Firing order is 1, 5, 3, 6, 2, 4. Breaker point gaps are set .015 and spark plug gap, .625.

Chevrolet ''490'' Electric System.

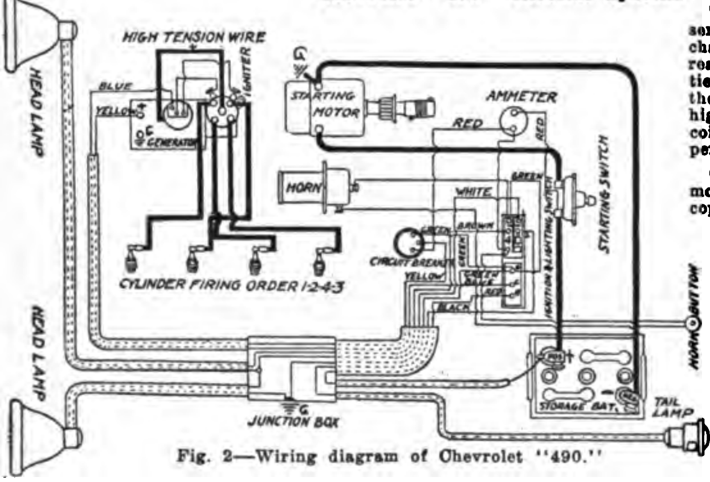


Fig. 2—Wiring diagram of Chevrolet ''490.''

The generator is a ''reversed series wound'' dynamo. Begins charging at 7 miles per hour, and reaches maximum current production at 20 miles, at which speed the amperage is about 14. At higher speeds the reversed series coil holds the output at this amperage.

Cutout or circuit-breaker—if removed, connect a short piece of copper-wire between terminal posts on generator, see chart 175AA for type cut-out used.

Ignition is the Connecticut as explained on page 254.

To time the ignition: Rotate the fly wheel until the No. 1 intake valve begins to open. Piston No. 1 is then at ''top center.''

After removing the spark plug and inserting a screw driver or rod as illustrated on page 686 continue to rotate the fly wheel until the piston again reaches top of its compression stroke.

Turn switch on and as in starting, slip the igniter on the shaft and connect the wires to their proper plugs, then remove the No. 1 wire from the terminal socket on the distributor case and hold it about one-quarter inch away from the brass ring of the socket, as in fig. 4.

Rotate the entire igniter assembly on the shaft in a clockwise direction, until a spark jumps from the end of the spark plug wire to the brass ring of the terminal. The igniter set screws should then be tightened, and the No. 1 wire inserted in its socket. Setting is made with spark lever retarded. Firing order, 1, 2, 4, 3.

On ''490'' Chevrolet xo adjustment of brushes on generator is provided. If generator fails to give its full output—see page 409. Later ''Auto-Lite'' generators have third brush regulation.

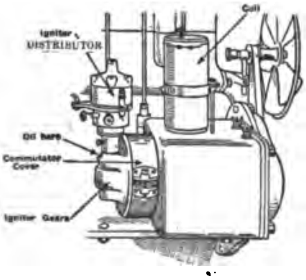


Fig. 3—Showing position of generator and ignition system. Also see pages 254 and 686.

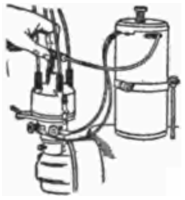
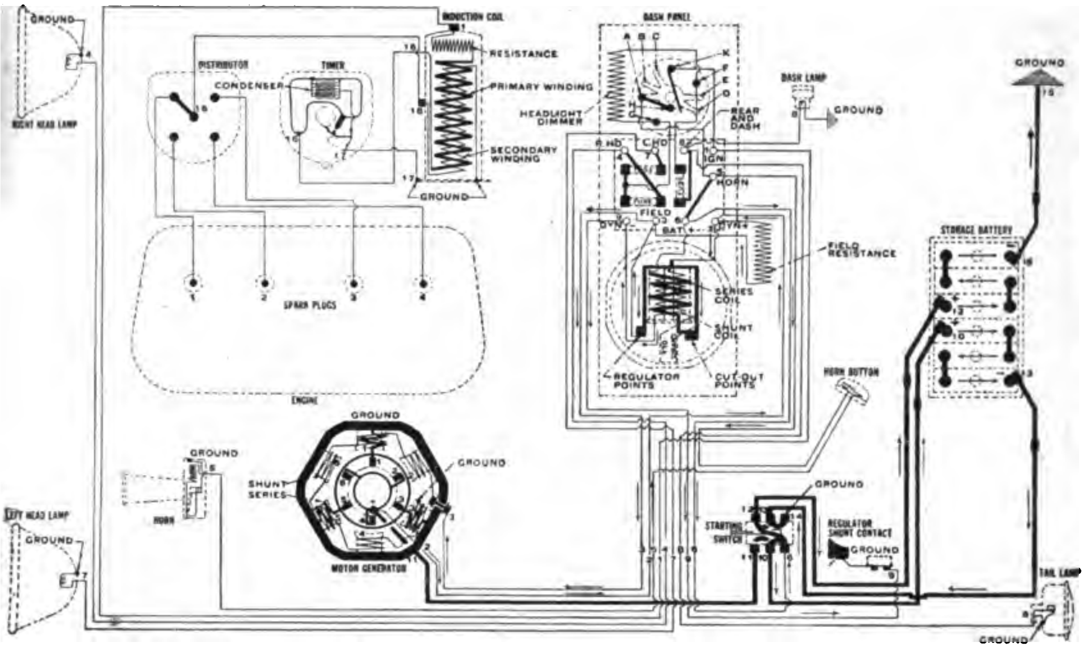


Fig. 4.

CHART NO. 179—Saxon ''6:'' Wagner Starter and Dynamo and Remy Ignition. Chevrolet ''490:'' Auto-Lite Starter with Bendix Drive and Auto-Lite Generator and Connecticut Ignition.



Maxwell Electric System.

Charging Circuit

On releasing the starting pedal the starting switch plunger comes all the way back and makes connection between 13 and 14, and 10 and 6 on the starting switch. In the meantime the terminal voltage of the generator has built up and the shunt winding of the cut-out and regulator has become energized thru circuit No. 2 from the generator positive to the fuse block (Dyn. +) and thru the shunt winding to terminal 9 (Dyn — Bat. —). From here the current passes to terminal 9 on regulator shunt contact, which is a grounded connection.

In the starting position this ground contact (No. 9) is broken so that the regulator will not become energized at the point of starting. As soon as the voltage reaches a pre-determined point, the energy of the shunt winding will cause the cut-out points to close and panel indicator to show "CHARGE."

The charging circuit will then be as follows: Starting at the + terminal on the motor generator, follow circuit No. 2 to Dynamo + on the fuse block, from there thru the cut-out arm, across the cut-out points, thru the series winding of the relay to terminal 6 (Bat. +) on the fuse block.

From this point follow circuit 6 to terminal 6 on starting switch, thru the switch contact and No. 10 to 10 on storage battery, thru storage battery to 13 to No. 13 on starting switch, thru contact to 14, which is grounded, at the same time follow circuit No. 6 thru permanent connection to 12 on starting switch, thence to 12 on storage battery, thru battery and No. 15 to 15 on frame, which is grounded.

Grounded connections 14 and 15 complete the circuit to the motor generator frame.

Regulation is accomplished by the vibrator points of the regulator alternately cutting in and short circuiting the field resistance on the dash panel.

With regulator points closed, the field circuit of the generator is from terminal 2 (Dyn. +) on the fuse block, thru the regulator arm; across the points to terminal 3 (Field) on the fuse block.

From here follow circuit No. 3 to 3 on the motor generator; thru the shunt windings to ground on pole piece 3.

With regulator points open the field circuit is from terminal No. 2 (Dyn. +) on fuse block thru the field resistance to terminal 3 (Field) on the fuse block, and follows circuit 3 as before.

Starting Circuit.

Under starting conditions the starting switch plunger is moved forward, and completes the circuit between 12 and 13 and between 11 and 10, the same movement meshing the starter pinion with the flywheel teeth.

The path of the current will then be as follows: Starting at the storage battery, from terminal 12 to terminal 12 on the starting switch; from 12 to 13 thru starting switch contacts; from 13 on starting switch to 13 on storage battery; thru storage battery to 10; from 10 on storage battery to 10 on starting switch; from 10 to 11 thru starting switch contacts; from 11 on starting switch to 11 on motor generator; that is, terminal marked +; from + terminal on motor generator to brushes 2, 4 and 6; thru armature windings to brushes 1, 3 and 5; thru the series windings on the respective pole pieces to ground.

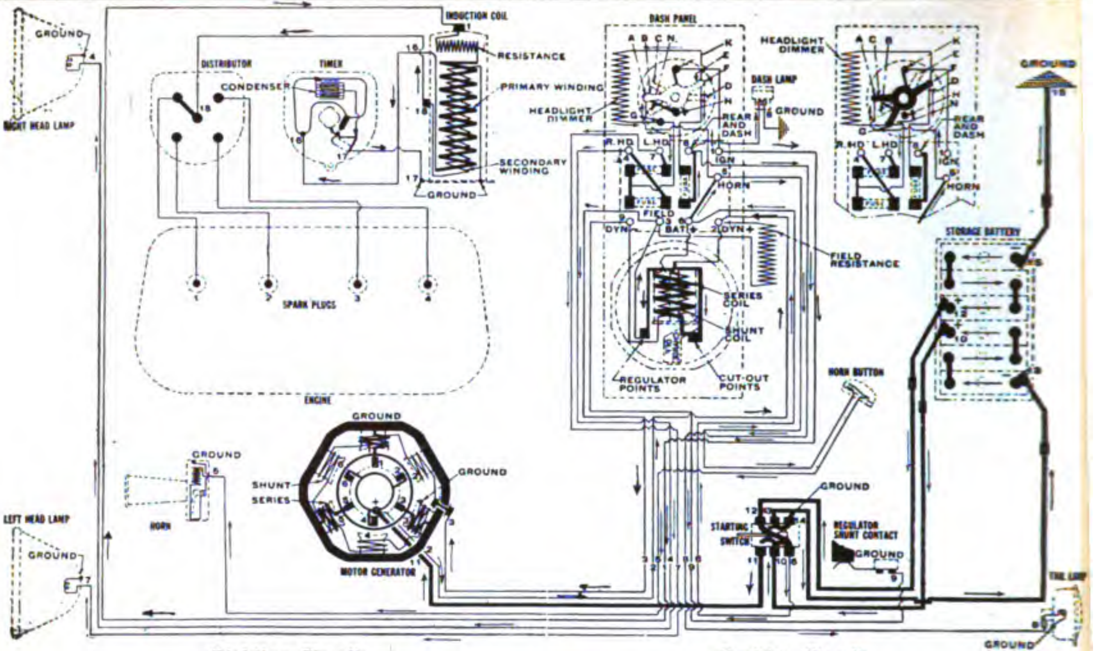
The windings on the six shunt coils pick up current as follows: Starting at the + terminal on the motor generator; thru circuit No. 2 to Dyn. + terminal on the fuse block; from there thru the regulator arm, and across the regulator points, which at this time make a full contact, and back to field terminal 3 on the fuse block.

From there following circuit 3 back to terminal 3 on the motor generator frame.

From this point thru the six shunt coils to ground on pole piece 3. The return circuit is from ground 15 on the frame to terminal 15 on the storage battery.

The cross connection between terminals 12 and 6, is a permanent one, and is not affected by movements of switch. This connection is made through the medium of a bus bar inside of switch box. Current for ignition, lights, and horn in supplied through this connection under starting conditions.

CHART NO. 180—Maxwell Model "25" Diagram Explaining the Charging and Starting Circuits.
See page 367 for specifications of this system.



Lighting Circuit.

The lighting switch spider in starting, charging, or ignition diagrams is shown in 'OFF'' position with spider arm ''N'' in contact with point ''A'' on back of lighting switch and with arms ''B,'' ''C,'' ''D'' and ''E'' free.

Lighting switch spider in complete dash panel of diagram above is in ''DIM'' position. In this position, spider arm ''B'' is in contact with point ''A,'' arm ''E'' is in contact with point ''F,'' and arms ''C,'' ''D'' and ''N'' are free.

When generator is not charging storage battery, current is supplied to lighting and horn circuits by storage battery and is delivered to switch panel from terminal 6 on starting switch to terminal 6 (Bat. +) on fuse block thru bus bar to terminal 5 (Horn). **When generator is charging battery,** current is supplied by generator to terminal 2 (Dyn. +) on fuse block, across cut-out points, thru series coil of regulator to terminal 6 (Bat. +) on fuse block and as before to terminal 5 (Horn).

Lighting circuit with spider in ''DIM'' position is from terminal 5 (Horn) to point ''A'' on lighting switch, thru spider arms ''B'' and ''E'' to point ''F'' on lighting switch.

Head light circuit is then from point ''F'' on lighting switch thru headlight dimmer coil to point ''G'' on lighting switch, to center of bus bar connecting right and left headlight fuse clips, thru fuses to terminals 4 and No. 7, right and left headlights, respectively, thru circuits 4 and No. 7 to right and left headlamps, respectively, and to ground.

Tail lamp circuit is from point ''F'' on lighting switch to tail lamp fuse, thru fuse to terminal 8 (rear and dash) on fuse block, from terminal 8 on fuse block to dash lamp and ground, also thru circuit 8 to tail lamp and ground.

Portion of panel shown to right of complete panel shows spider in ''ON'' position. Spider arm ''C'' is in contact with point ''A,'' arm ''N'' in contact with point ''G,'' and arm ''D'' in contact with point ''F,'' arms ''B'' and ''E'' being free.

Lighting circuit is now from terminal 5 (Horn) on fuse block to point ''A,'' thru spider arm ''C'' as before. Headlight current follows circuit thru spider arm ''N'' to point ''G,'' and to headlights from point ''G'' as before. Tail light current follows circuit thru spider arm ''D'' to point ''F'' and to tail and dash lamps as before.

The electric horn circuit is as follows: Starting at terminal 6 (Bat. +) follow bus bar to terminal 5 (Horn) thru circuit 5 to horn button and to insulated terminal on horn, thru magnet winding of horn across contact points to ground and thence to storage battery.

Ignition Circuit.

By inserting the ignition-key in the lighting and ignition-switch, the ignition circuit is closed. The ignition primary current for starting the engine is supplied by both halves of the storage battery, connected in parallel and is delivered to the ignition-switch from terminal 6 on starting switch to 6 (Bat. +) on fuse block, the remainder of the primary circuit being as follows:

From terminal 6 (Bat. +) on fuse block to terminal 5 on fuse block, to point ''A'' on back of lighting switch, from point ''A'' to point ''H'' on back of lighting switch through ignition switch contact spring to point ''K'' on back of lighting switch and to terminal 1 (Ign.) on fuse block; from terminal 1 on fuse block through circuit 1 to terminal 1 on top of induction coil, through primary winding of induction coil to point 16 on coil, to terminal 16 on condenser cover at the timer.

From terminal 16 on condenser cover the current flows through condenser cover (shown in outline) to the timer breaker points, and from the timer breaker points to point 17 on the timer, the contact breaker spring serving as the circuit. Point 17 on timer to point 17 at base of induction coil and ground completes the circuit.

Under running conditions when speed of generator is such that voltage generated closes cut-out points for charging the storage battery, the ignition primary current is supplied directly from the generator to terminal 2 (Dyn. +) on fuse block across cut-out points through regulator to terminal 6 (Bat. +) on fuse block, from which point the circuit is the same as under starting conditions.

A condenser is connected directly across the breaker points, and while no current flows through it, it is an absolute necessity in order to get the proper performance of the induction coil.

At the instant the timer breaker points separate a high tension current is induced in the secondary winding. This high tension current leaves the induction coil at terminal 18.

The high tension current circuit can be traced from terminal 18 on induction coil to center terminal 18 on distributor cover where it is distributed to the separate spark plugs, across the spark plug gap to ground and thence back to the secondary winding.

Switch arms: The lettering of these arms is some what confusing. On diagram one would be led to believe that arms are lettered A, B, C, E, and D, but such is not the case however. The lower left-hand arm is N, and is shown resting on contact point A in chart 180 and on point G in the portion of panel shown in upper right corner of this chart.

IART NO. 180A—Maxwell Lighting and Ignition Circuits—continued in chart 180B.

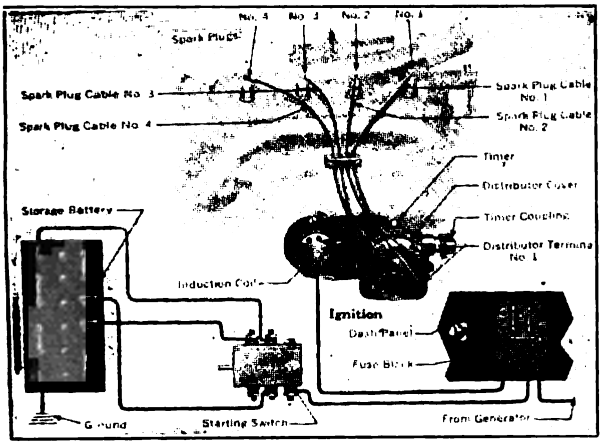


Fig. 2. Maxwell Ignition System.

Specifications of Maxwell Electric System.

Maxwell "25" electric system as explained in charts 180 and 180A, consists of a Simms-Huff starting motor and generator combined in one unit. It has a single armature. The two field windings (shunt and series) are differentially wound, hence it is called a "differential compound generator."

Generator:—When the engine is running, the dynamo delivers its charging current (10 to 15 amperes) to the battery at 6 volts (2 halves, 6 volts each, in parallel), operating as a differential compound generator, that is, its two fields oppose each other, so the terminal voltage and consequently the charging current is not excessive at the higher speeds. This likewise decreases the steady load on the engine, since torque developed through opposition of fields is considerably lessened.

In starting the engine the dynamo draws its heavy current from the same battery and acts as cumulative compound motor. The starter switch connects the two halves of battery in series, thus delivering 12 volts to starting motor.

The Cut-Out and Regulator are mounted on the rear of dash panel carrying the "off" and "charge" indicator and switch. The cut out and regulator action is explained in chart 180. **Should cut out points stick** at, any time it will be indicated by indicator showing "charge" and generator continuing to run after engine is stopped.

Wiring—The Maxwell starting and lighting system is a grounded one, that is, the frame is used as the **return** circuit from starter, lights, horn, etc.

Should light fuses blow persistently or battery discharge over-night, examine wiring carefully for a short circuit. If indicator does not indicate charge with engine running above 15 miles per hour, or when engine is speeded up, it is a sure indication of a broken wire or loose connection somewhere and should be attended to immediately.

In a complete breakdown of the lighting system, circuit should immediately be tested for a break, or **ground,** as this wire carries the current for all lamps and horn.

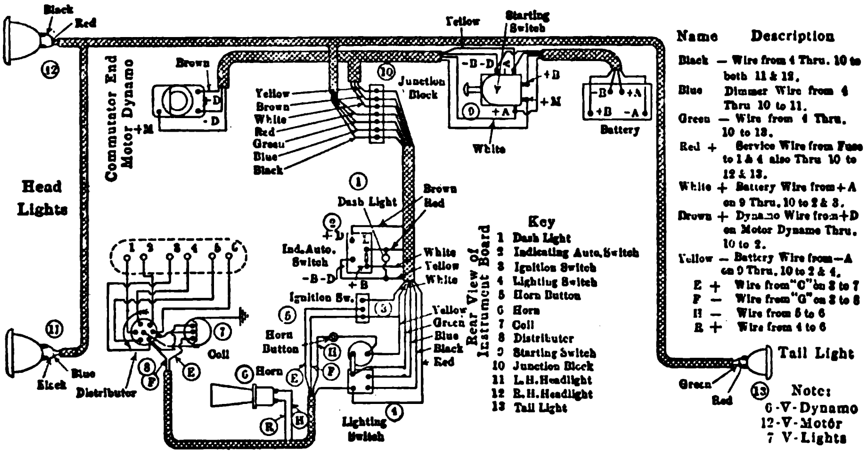
When individual lamps fail the trouble should be looked for in the wire between the dash and panel and the unit which fails to work. 7 or 8 **volt, single contact lamps** are used.

Ignition Timing on Maxwell.

Fig. 2. Atwater-Kent ignition on Maxwell 25. (See chart 117,) located on the right side of engine and driven by the timing gears. The current is taken from the generator at driving speeds and from the storage battery under starting conditions. Operated on 6 volts.

Timing the spark: (If coupling has not been loosened on timer coupling shaft): Turn the crank shaft with the hand crank until No. 1 piston is 1/32 inch past top dead center, or 1¼ inch past on the flywheel, on compression or firing stroke. With No. 1 piston in this position notch in drive shaft half of coupling should be up. Remove the distributor cover. which is held in place by means of two spring clips and turn the timer coupling shaft until the distributor arm is brought into position opposite No. 1 segment in distributor cover. The front right terminal on distributor cover is No. 1. Turn timer coupling shaft to right or left until coupling pin is in position to engage in drive shaft coupling notch. With timer in this position couple it to the engine, bolt to bracket, and connect the terminals in the proper firing order of the engine, viz., from left to right, or clockwise, No. 1, 3, 4, 2.

(If coupling has been loosened on timer coupling shaft.) Place No. 1 piston and distributor arm in position as explained above. Retard the breaker and turn the timer coupling shaft until the platinum points just break, or in other words, just separate. Holding coupling shaft in this position, turn coupling on shaft until coupling pin is opposite notch in drive shaft half of coupling and tighten coupling clamp screw. Couple timer to engine and connect terminals as previously explained.



Key
1 Dash Light
2 Indicating Auto. Switch
3 Ignition Switch
4 Lighting Switch
5 Horn Button
6 Horn
7 Coil
8 Distributor
9 Starting Switch
10 Junction Block
11 L. H. Headlight
12 R. H. Headlight
13 Tail Light

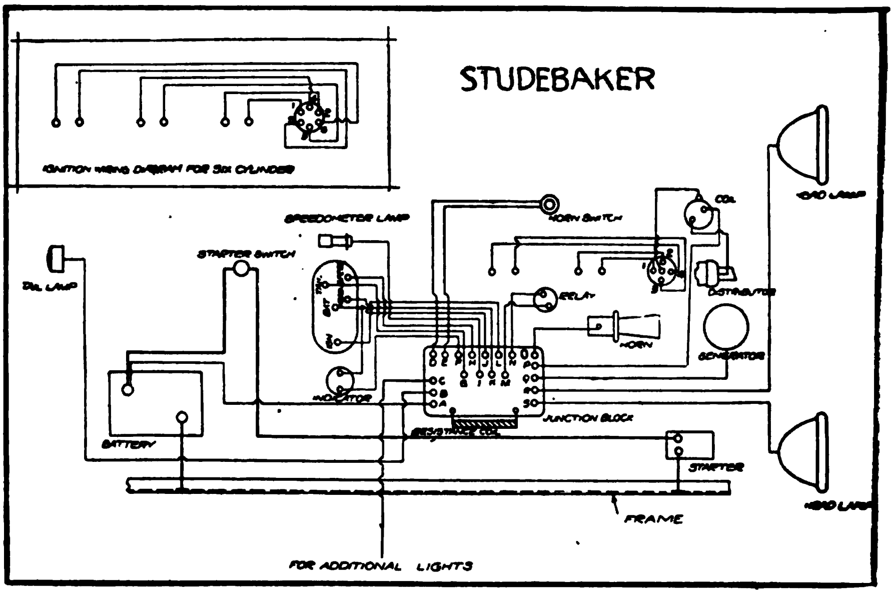
Name		Description
Black	—	Wire from 4 Thru. 10 to both 11 & 12.
Blue		Dimmer Wire from 4 Thru 10 to 11.
Green	—	Wire from 4 Thru. 10 to 13.
Red	+	Service Wire from Fuse to 1 & 4 also Thru 10 to 12 & 13.
White	+	Battery Wire from + A on 9 Thru. 10 to 2 & 3.
Brown	+	Dynamo Wire from + D on Motor Dynamo Thru. 10 to 2.
Yellow	—	Battery Wire from — A on 9 Thru. 10 to 2 & 4.
E	+	Wire from "C" on 3 to 7
F	—	Wire from "G" on 3 to 8
H	—	Wire from 5 to 6
R	+	Wire from 4 to 6

Note:
6-V-Dynamo
12-V-Motor
7 V-Lights

Mitchell A-29: Splitdorf-Apelco starter and generator. Connecticut ignition (6 volts). **Starting motor 12 volt. Lights 7 volt. Mitchell "6-40" uses a Westinghouse starter and generator.**

CHART NO. 180B—Maxwell Ignition System—continued. **Mitchell-Lewis A-29. Electric System**

For latest electric systems used on late model cars of different makes, see pages 543 to 546.



Studebaker Electric System.

The starting motor is connected to engine by gears integral with the starting motor (see fig. 1, chart 164). A roller chain transmits the power to a sprocket on the crank shaft. The latter sprocket operates through an "over-running clutch" on the crank shaft.

***The generator** is mounted in a vertical position on the right side of engine (G, page 204), and is operated by a spiral gear from timing gears. It begins to deliver current to the battery at a car speed of about 10 miles per hour and reaches a maximum rate of flow at about 18 miles per hour.

Generator is oiled at bearings every 2000 miles with light machine oil. (See page 204 for lubrication of entire car.)

Out-out—also called a relay, is of the usual type, and is attached to the dash.

The relay will require no attention unless the battery indicator shows **discharging** when no current is being used for lights, horn, or ignition. If this should happen, remove the relay cover and examine the contact points to see if they are stuck together. If they are, they should be separated and dressed if rough.

The method of wiring used throughout, is the grounded return, or so-called one-wire system. In this system there is but one insulated wire circuit from the battery to each electrical unit. **If any of the wires should be removed in making repairs,** make connections as shown under car wiring diagram above. When repairing wiring or electrical parts, first disconnect wires from battery to prevent possibility of short circuit.

If it is desired to operate the car without a storage battery a set of four dry cells may be installed in the place of the battery, connecting them to the terminal of the large cable riveted to the frame, and to the terminal of the smaller of the two cables disconnected from the negative storage battery terminal. Any use of the lights or horn under these conditions will serve to discharge the dry cells rapidly. If the storage battery is removed it is vitally necessary, to take the following precaution.

If for any reason the engine is to be operated with the generator disconnected from the storage battery, be sure to connect the terminal of the generator to some point on the metal frame of the generator or engine, using a piece of copper wire. This precaution is for the protection of the generator and is essential. This "ground" wire should be removed when the generator is again connected to the storage battery.

Lamps: For headlamps use 7-volt 12-candle-power bulbs, and for tail and speedometer lamps use 7-volt 2-candle-power bulbs.

Ignition: is the Remy—see page 251. **The ignition unit,** is mounted to the front of the engine, and driven by gears at half crank shaft speed. Coil is mounted to the side of the distributor.

Adjustments: contact points should be .015 of an inch. Spark plugs .025 inch gap.

Timing the spark: Open the pet-cock on top of the cylinders and turn the engine over by hand until the piston in No. 1 cylinder has begun its compression stroke. The beginning of the compression stroke may be detected by holding the thumb over the open pet-cock until compression is felt. The exact upper dead center position is indicated by the mark "UP-D-C-1" on the flywheel coming under the pointer at the top of flywheel. Turn over the engine until this mark has 4 inches to travel (for the four) or 5½ inches to travel (for the six) before reaching the pointer. The engine is now in the proper position for the fully advanced spark in No. 1 cylinder.

Turn the spark lever on the steering wheel to its extreme advanced position. The timer control lever should then be in its extreme forward position.

Remove the distributor cover without disconnecting the wires, lift off the distributing segment holder, and loosen the nut which holds the cam on the tapered shaft.

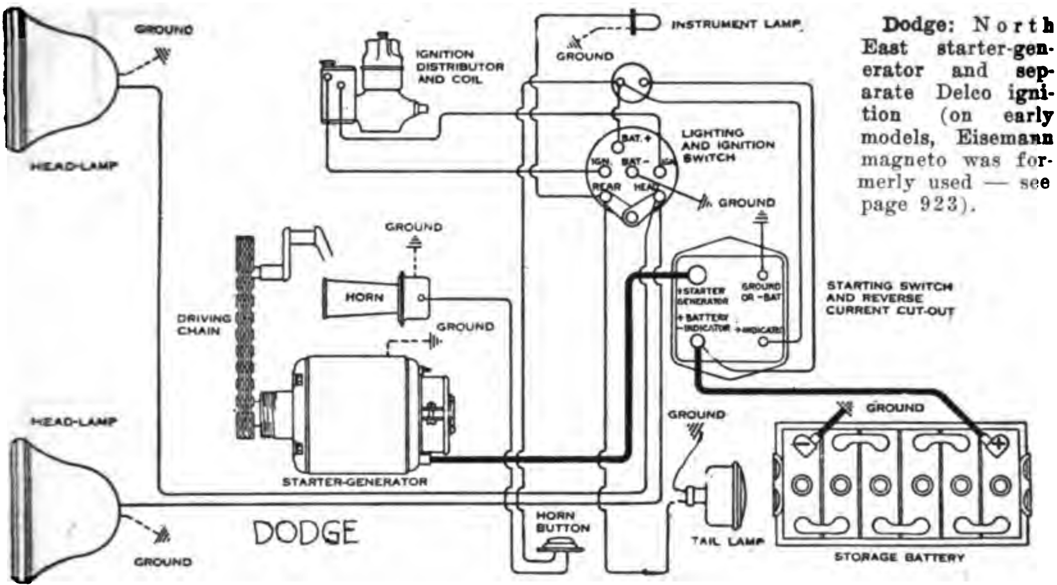
Pry the cam from its seat on the shaft, using the special tool which will be found in the regular tool kit.

Turn the cam in a anti-clockwise direction until it reaches a position such that when all parts are replaced the edge of the distributing segment will come directly under No. 1 distributor terminal. Then continue turning until the breaker points are just in the act of separating.

Tighten the lock nut to hold the cam in this position and replace the distributing segment holder and cover.

*See chart 116 and 164 for the 1915-16 Studebaker electric drive principle.

CHART NO. 180C—Studebaker Electric System: Wagner Starter and Generator—Remy Ignition.
Above is 1916-17 Studebaker. 1918 system similar.



Dodge: North East starter-generator and separate Delco ignition (on early models, Eisemann magneto was formerly used — see page 923).

*Dodge Electric System.

Starter—Generator: position, front left hand side of engine. 12 volts.

One armature and two sets of field windings. Operating both as a starter and as a generator. Driven by means of a silent chain. Ratio of 3 to 1. (Also see chart 181A.)

Ignition: Delco, distributor on right side of engine, driven by water pump shaft. Distributor of course is driven at ½ crank shaft speed. The system is similar to other Delco ignition systems. **Firing order** is 1, 3, 4, 2. **Spark plug** gaps are separated 1/32 inch, or about thickness of a smooth dime. **Wiring**—grounded or single wire system.

To time the ignition: Open all the priming cups. and crank the engine until the compression stroke begins in cylinder No. 1.

This can be ascertained by holding the thumb tightly over the priming cup of this cylinder and observing that both the valves remain closed at the top of the stroke.

Slowly continue to turn over the crank until piston No. 1 has passed the top of this stroke about 5°, which is ⅝ inch past dead center measured on the flywheel. This position can be determined without removing the cylinder head, by turning the starting crank handle until the exhaust valve in cylinder No. 4 just closes.

Remove the distributor head and distributor rotor. and loosen the breaker cam adjusting screw on the top of the vertical shaft.

Then set the breaker cam in such a position that the rotor button will come under the position of No. 1 cylinder high tension terminal in the distributor head when it is replaced on the breaker cam, and so that the timing contacts are just starting to open with the spark lever in the fully retarded position.

Set the breaker cam carefully so that when the slack in the distributor gears is rocked forward, the timing contacts will open, and when the slack is rocked backward, these contacts will just close.

With the vertical shaft in the proper position in reference to the engine,- and the breaker cam and distributor rotor both set as instructed, the timing adjusting screw should be screwed down tightly. Then replace the rotor and distributor head. See that the rotor button spring allows the button to be fully depressed, and that the distributor head is located properly by the locating tongue which snaps onto it.

Chain Adjustment of Starter-Generator.

To obtain the proper adjustment for quiet running of the chain, proceed as follows: (see also page 411.)

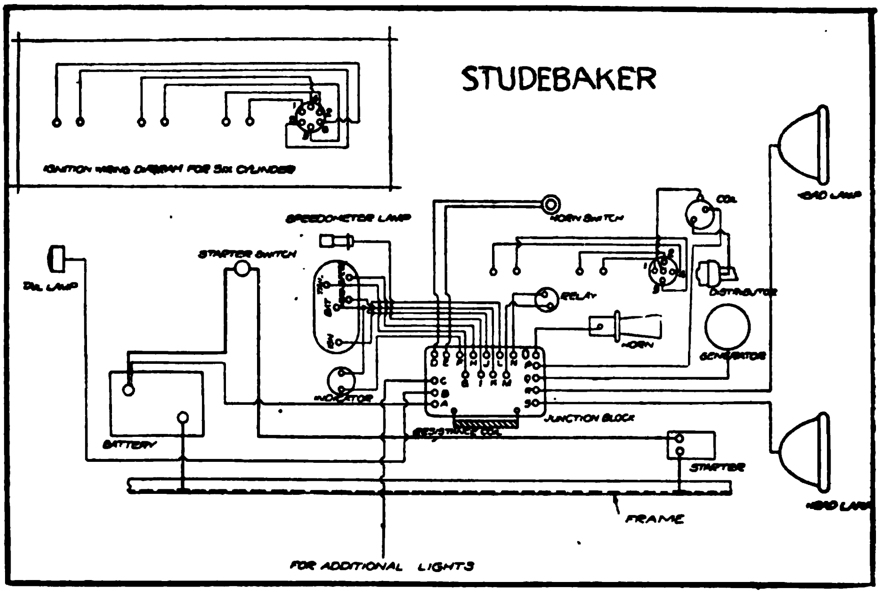
Loosen the set screw and lock nut on the edge of the front flange of the cylinder block. and back off the starter binding nut, just enough to remove the pressure from the adjusting ring. Loosen the "V" blocks and strap to allow the starter-generator to move. This will allow the eccentric adjusting ring. to be turned until the required play in the chain is obtained. There should be about one-half inch up and down movement in the chain. After the proper adjustment has been made, be sure that the set screw, lock nut, and binding nut are screwed up tightly. See that the chain tension has not been disturbed while performing this last operation.

Carefully adjust "V" blocks up snug between engine and starter-generator, and then tighten holding strap. After the inspection cover has been replaced the chain should run without perceptible noise. It is lubricated by dipping into the oil in the bottom of the front gear compartment; thus needing no further attention after it has been properly adjusted.

—continued in chart 181A.

CHART NO. 181—Dodge Electric System.

*See also pages 923. 924.



Studebaker Electric System.

The starting motor is connected to engine by gears integral with the starting motor (see fig. 1, chart 164). A roller chain transmits the power to a sprocket on the crank shaft. The latter sprocket operates through an "over-running clutch" on the crank shaft.

***The generator** is mounted in a vertical position on the right side of engine (G, page 204), and is operated by a spiral gear from timing gears. It begins to deliver current to the battery at a car speed of about 10 miles per hour and reaches a maximum rate of flow at about 18 miles per hour.

Generator is oiled at bearings every 2000 miles with light machine oil. (See page 204 for lubrication of entire car.)

Cut-out—also called a relay, is of the usual type, and is attached to the dash.

The relay will require no attention unless the battery indicator shows **discharging** when no current is being used for lights, horn, or ignition. If this should happen, remove the relay cover and examine the contact points to see if they are stuck together. If they are, they should be separated and dressed if rough.

The method of **wiring** used throughout, is the grounded return, or so-called one-wire system. In this system there is but one insulated wire circuit from the battery to each electrical unit. **If any of the wires should be removed in making repairs,** make connections as shown under car wiring diagram above. When repairing wiring or electrical parts, first disconnect wires from battery to prevent possibility of short circuit.

If it is desired to operate the car without a storage battery a set of four dry cells may be installed in the place of the battery, connecting them to the terminal of the large cable riveted to the frame, and to the terminal of the smaller of the two cables disconnected from the negative storage battery terminal. Any use of the lights or horn under these conditions will serve to discharge the dry cells rapidly. If the storage battery is removed it is vitally necessary, to take the following precaution.

If for any reason the engine is to be operated with the generator disconnected from the storage battery, be sure to connect the terminal of the generator to some point on the metal frame of the generator or engine, using a piece of copper wire. This precaution is for the protection of the generator and is essential. This "ground" wire should be removed when the generator is again connected to the storage battery.

Lamps: For headlamps use 7-volt 12-candle-power bulbs, and for tail and speedometer lamps use 7-volt 2-candle-power bulbs.

Ignition: is the Remy—see page 251. **The ignition unit,** is mounted to the front of the engine, and driven by gears at half crank shaft speed. Coil is mounted to the side of the distributor.

Adjustments: contact points should be .015 of an inch. Spark plugs .025 inch gap.

Timing the spark: Open the pet-cock on top of the cylinders and turn the engine over by hand until the piston in No. 1 cylinder has begun its compression stroke. The beginning of the compression stroke may be detected by holding the thumb over the open pet-cock until compression is felt. The exact upper dead center position is indicated by the mark "UP-D-C-1" on the flywheel coming under the pointer at the top of flywheel. Turn over the engine until this mark has 4 inches to travel (for the four) or 5⅛ inches to travel (for the six) before reaching the pointer. The engine is now in the proper position for the fully advanced spark in No. 1 cylinder.

Turn the spark lever on the steering wheel to its extreme advanced position. The timer control lever should then be in its extreme forward position.

Remove the distributor cover without disconnecting the wires, lift off the distributing segment holder, and loosen the nut which holds the cam on the tapered shaft.

Pry the cam from its seat on the shaft, using the special tool which will be found in the regular tool kit.

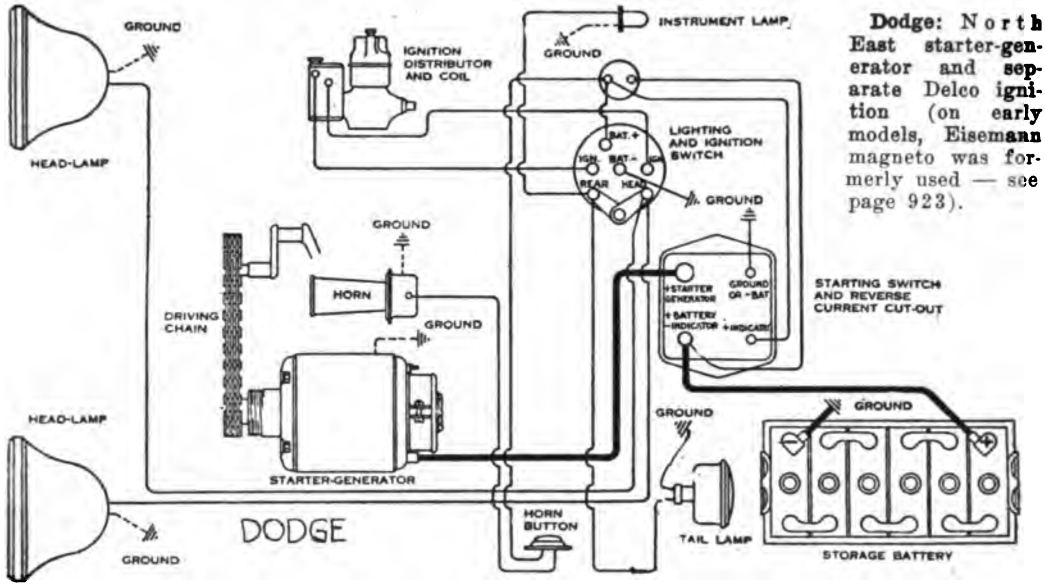
Turn the cam in a anti-clockwise direction until it reaches a position such that when all parts are replaced the edge of the distributing segment will come directly under No. 1 distributor terminal. Then continue turning until the breaker points are just in the act of separating.

Tighten the lock nut to hold the cam in this position and replace the distributing segment holder and cover.

---

*See chart 116 and 164 for the 1915-16 Studebaker electric drive principle.

CHART NO. 180C—Studebaker Electric System: Wagner Starter and Generator—**Remy Ignition.**
Above is 1916-17 Studebaker. 1918 system similar.



Dodge: North East starter-generator and separate Delco ignition (on early models, Eisemann magneto was formerly used — see page 923).

*Dodge Electric System.

Starter—Generator: position, front left hand side of engine. 12 volts.

One armature and two sets of field windings. Operating both as a starter and as a generator. Driven by means of a silent chain. Ratio of 3 to 1. (Also see chart 181A.)

Ignition: Delco, distributor on right side of engine, driven by water pump shaft. Distributor of course is driven at ½ crank shaft speed. The system is similar to other Delco ignition systems. **Firing order** is 1, 3, 4, 2. **Spark plug** gaps are separated 1/32 inch, or about thickness of a smooth dime. **Wiring**—grounded or single wire system.

To time the ignition: Open all the priming cups, and crank the engine until the compression stroke begins in cylinder No. 1.

This can be ascertained by holding the thumb tightly over the priming cup of this cylinder and observing that both the valves remain closed at the top of the stroke.

Slowly continue to turn over the crank until piston No. 1 has passed the top of this stroke about 5°, which is ⅝ inch past dead center measured on the flywheel. This position can be determined without removing the cylinder head, by turning the starting crank handle until the exhaust valve in cylinder No. 4 just closes.

Remove the distributor head and distributor rotor, and loosen the breaker cam adjusting screw on the top of the vertical shaft.

Then set the breaker cam in such a position that the rotor button will come under the position of No. 1 cylinder high tension terminal in the distributor head when it is replaced on the breaker cam, and so that the timing contacts are just starting to open with the spark lever in the fully retarded position.

Set the breaker cam carefully so that when the slack in the distributor gears is rocked forward, the timing contacts will open, and when the slack is rocked backward, these contacts will just close.

With the vertical shaft in the proper position in reference to the engine, and the breaker cam and distributor rotor both set as instructed, the timing adjusting screw should be screwed down tightly. Then replace the rotor and distributor head. See that the rotor button spring allows the button to be fully depressed, and that the distributor head is located properly by the locating tongue which snaps onto it.

Chain Adjustment of Starter-Generator.

To obtain the proper adjustment for quiet running of the chain, proceed as follows: (see also page 411.)

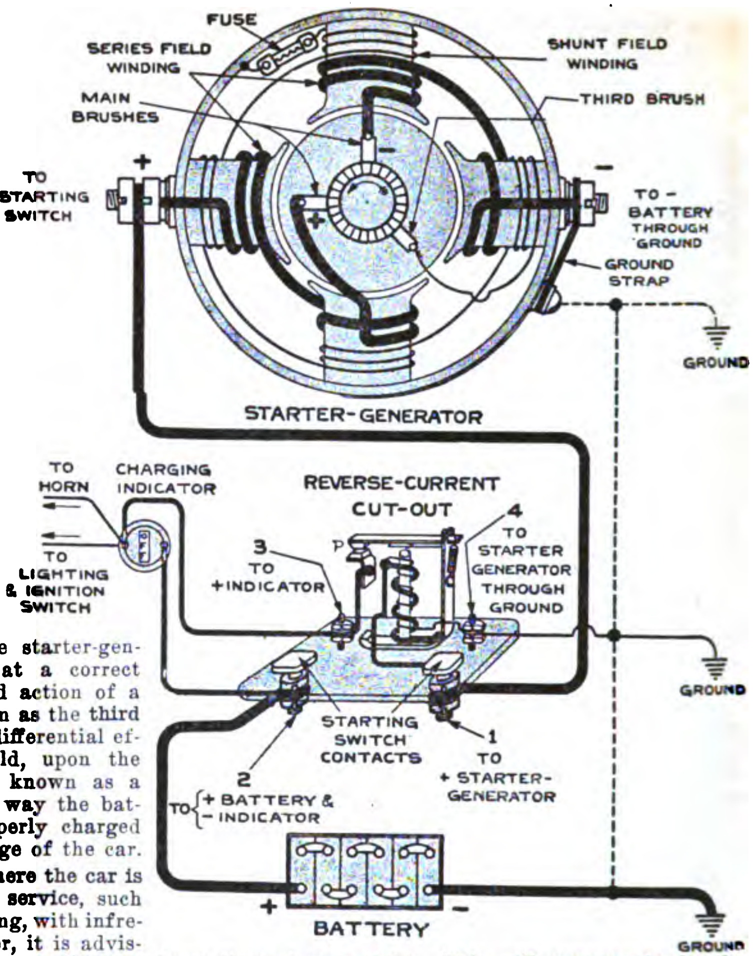
Loosen the set screw and lock nut on the edge of the front flange of the cylinder block, and back off the starter binding nut, just enough to remove the pressure from the adjusting ring. Loosen the "V" blocks and strap to allow the starter-generator to move. This will allow the eccentric adjusting ring, to be turned until the required play in the chain is obtained. There should be about one-half inch up and down movement in the chain. After the proper adjustment has been made, be sure that the set screw, lock nut, and binding nut are screwed up tightly. See that the chain tension has not been disturbed while performing this last operation.

Carefully adjust "V" blocks up snug between engine and starter-generator, and then tighten holding strap. After the inspection cover has been replaced the chain should run without perceptible noise. It is lubricated by dipping into the oil in the bottom of the front gear compartment; thus needing no further attention after it has been properly adjusted.

—continued in chart 181A.

CHART NO. 181—Dodge Electric System.

*See also pages 923, 924.



Generating: As soon as the car attains a speed of approximately 10 miles per hour the automatic cut-out located in the starting-switch housing automatically closes the circuit between the starter-generator and the battery, thus allowing a charging current to be conducted from the starter-generator to the battery. Whenever the car speed falls below 9 to 10 miles per hour the cut-out automatically opens the generating circuit and prevents the battery from discharging through the starter-generator, except, of course, when the starting switch is operated.

The output from the starter-generator is maintained at a correct value by the combined action of a **regulating** device known as the third **brush system,** and the differential effect of the series field, upon the shunt field, commonly known as a bucking field. In this way the battery is kept in a properly charged state under normal usage of the car.

In cases, however, where the car is **subjected to abnormal service,** such as continuous day driving, with infrequent use of the starter, it is advisable occasionally to allow the lights to burn dimmed over night. This will compensate for the abnormal charge given the battery. The same results may be obtained by allowing the starter-generator to run the engine with the ignition turned off for a period of five to fifteen minutes.

Under extreme conditions. it may be necessary to have the charging rate of the starter-generator changed slightly, so as either to decrease or increase the charge given the battery, to meet the special requirements of the case. This alteration of the charging rate can be quickly made by **adjusting the third brush system,** (similar to adjusting Delco third brush, see index.)

The current indicator is located on the left hand side of the instrument board. and is inserted in the charging circuit, between the automatic cut-out and the positive battery connection of the starting switch. To the positive terminal on the current indicator are connected the wires which conduct the current for the ignition and lighting switch and for the horn.

This indicator registers "charge" when the starter-generator is charging the battery, and "Discharge" when the battery is supplying current for the ignition or lighting systems. Whenever the starter-generator is supplying normal current to the battery however, the indicator will show "charge" even if all the lamps are burning. "Discharge" will appear on the indicator whenever the lights are being used while the car is standing, or running on direct drive at a speed of less than 10 to 12 miles per hour.

If at any time the current indicator fails to register properly, inspect its terminal posts to see that the wires leading thereto are tightly attached. Also, make sure that there are no short circuits in the wiring system.

The showing of "Discharge" instead of "charge" when the latter should be indicated. is an almost certain sign that a short circuit has developed in the wiring system unless, of course, the wires attached to the current indicator, have been connected to its terminals in such a way as to reverse the direction of flow of the current through the indicator.

If no short circuit in the car wiring is to be found remove the current indicator, and inspect it for internal difficulties. Be sure to replace properly all connections before again running the engine.

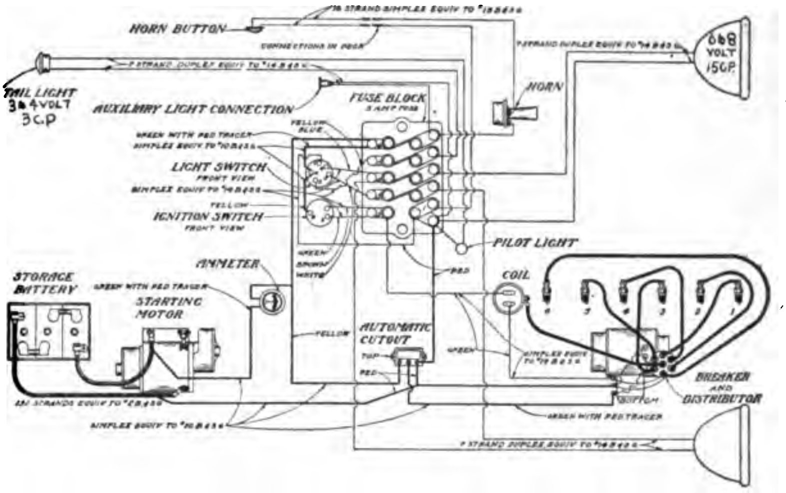
Lighting system: single grounded return system is used, see chart 197 for size lamps used. Lighting switch has three positions; "off," "dim" and "on." For disconnecting battery or generator—see index "disconnecting battery" and "disconnecting generator."

HART NO. 181A—North East Electric System on the Dodge—continued.

Reo Electric System.

The Remy electric starter, generator, and ignition system is used on both the four, and six, cylinder Reo. The construction is similar on both cars. (see this chart and chart 181C.)

The starting motor has a gear reduction built integral with starting-motor. The power is transmitted to transmission main shaft by means of a roller chain and sprocket. (see fig. 3, page 336.)



When the starting button is depressed, a lever tightens the friction cable, which passes around a sheave mounted beside the starting motor chain sprocket on the transmission. This cable holds the sheave until a slot in it engages a trip pin connected to a pawl on this sprocket. When this trip pin makes contact with the side of the slot it twists the pawl and brings it into mesh with the teeth of a ratchet on the universal shaft. The universal shaft and the sprocket then turn as a unit until the starting button is released, freeing the sheave and permitting a spring to disengage the pawl from the ratchet.

Generator, is a low speed 6 volt, machine, with the Remy ignition unit, as explained in chart 118, and page 251, also in chart 169. The thermostatic control is mounted on the generator.

The automatic cut-out is located on the dash beneath the hood and is for the purpose of preventing current from the storage battery flowing back through the generator when it is standing still, or running at a speed lower than 300 R. P. M. or about five miles per hour in high gear. The cut-out requires no adjustment other than to keep the points clean and smooth with contact the full width. Do not under any condition alter the spring tension. Do not close the cut-out points when the engine is not running as they will stick together and allow the battery to be discharged in a few hours time as well as ruining the cut-out coil.

Regulation of output.—This generator is equipped with "third brush regulation" and means are provided for varying the maximum output. A small screw which is located in the rear end of the generator is connected to the third brush by a rack and pinion movement, which allows the position of the brush on the commutator to be changed slightly. Turning this screw in a clockwise direction increases the output for a given speed while turning it in the opposite direction decreases it.

Thermostatic control.—In order to provide against a shortage of current in winter weather or on short runs where starts are numerous and at the same time to insure against overheating the generator in the summer or on long runs a thermostat is arranged to cut down the charging rate as soon as the temperature of the generator reaches a certain point. This thermostat can be seen by removing the cover from the rear of the generator, and since it requires no adjustment should not be tampered with, (see chart 169.)

Amount of charge.—The generator is in normal working condition if the ammeter shows a charge of about 18 amperes, when running 15 miles per hour on first starting and reduces this charge to about 10 amperes on becoming warmed up.

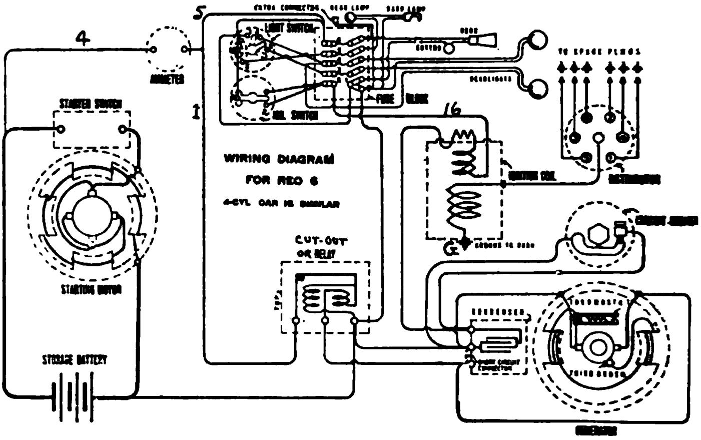
Condenser.—The condenser is contained in the metal box mounted on the side of the generator. This places it within a few inches of the breaker points which is very desirable. The condenser terminals are the two upper ones on the end of the box. The two lower terminals are connected to the armature, and the clip marked "Short Circuit Connector" is for the purpose of connecting these terminals, if it is desired, at any time, to run the engine without generating current.

Brushes.—The brushes are of special copper carbon composition and should last indefinitely. If replacement should be necessary from any cause, do not use carbon substitutes, but obtain the special brushes furnished by the Remy factory, branch house or service stations. Brushes should be kept tight on the holders and in perfect contact with the commutator.

—continued in charts 181C and 181D.

CHART NO. 181B—Reo Electric System—The Remy.

—**Reo continued.**



The ammeter is for the purpose of indicating the amount of current passing into and out of the storage battery. The indicator or hand should point to zero at the center of the scale when the engine is standing still and all lighting or ignition switches are in the "off" position. If it does not, it is almost conclusive proof that there is a leakage of current tending to run down the battery, but in order to make certain that the ammeter is not at fault, disconnect one of the battery terminals at the battery. This prevents any current from flowing and the ammeter will, if it is all right, indicate zero or very closely to it.

If the ammeter indicator is off from this zero position, then the difficulty is in the ammeter and it may be corrected by removing the ammeter from the case and resetting by bending the hand. There is very little chance of this type of ammeter reading incorrectly as ordinary short circuits have little or no detrimental effect, since only a small part of the current is shunted through the coil attached to the indicator and this current does not affect the permanent magnet. However, an unusually heavy short circuit will burn the coil or balancing springs.

Leakage.—If the ammeter shows zero reading with the battery disconnected and shows a discharge reading with battery connected, engine standing still and all switches in the off position, then there is a leakage of current.

This leak should be found and stopped at once or the storage battery will become discharged and if allowed to remain in this condition for any length of time, cause injury to the battery.

These leaks are most likely to be found in the lighting wires, sockets, and connections and in the ignition wires. Leaks in that section of wires between ammeter and battery are not registered on the ammeter, which should be borne in mind when looking for battery trouble.

The ammeter does not show the amount of current used by the starting motor. The starting motor takes about 95 amperes to turn the engine over at approximately 125 revolutions per minute. This current is used, of course, only for a few seconds and it is not considered necessary or advisable to try to pass it through the ammeter.

The ammeter does not show the amount of current in the battery. A hydrometer is the only instrument that will show this.

Generator disconnected: if wires running to the generator should be disconnected for any cause, great care should be used in replacing them—generator will reverse its polarity if wires are reversed—no serious injury would result, but ignition current might be interfered with.

Fuse block—If a fuse burns out—find the cause. Replace with 5 ampere fuses. **Bulbs:** headlight, 6 to 8 volt, 15 c. p. Dash and tail lights, 3 to 4 volt, 3 c. p.

Disconnecting storage battery: If the storage battery (3 cell, 6 volt) should become discharged to such an extent that it fails to supply ignition current it should be recharged from an outside source of current. If absolutely necessary to use the car with battery removed place five dry cells, connected in series, in place of the storage battery, connecting to the same terminals. Connect the two lower terminals on the condenser box (located on the side of the generator), together by the short circuit clip which should be found attached to the lower terminal or by a piece of wire and the car can be used until storage battery is recharged; it, of course, being necessary to crank the engine by hand. It should be remembered that it is often possible to start an engine by hand cranking even after the storage battery is too weak to drive the starting motor.

If battery is removed, be sure and replace it as it was originally—same connections and be sure they are tight.

Ignition—the Remy battery and coil system is explained in chart 118 and page 251.

Adjustments: maximum opening of breaker points .012 to .015 inch. The re-bound spring should be .020 inch, from the breaker arm, when points are at maximum opening. Spark plug gap .025 to .030 inch.

—continued in chart 181D.

CHART NO. 181C—Reo Electric System—The Remy—continued.

—continued from chart 181C.

If the engine misses when running idle or pulling light, the spark plug gaps should be made wider. If the engine misses at high speed or when pulling heavy, at low speed, the gaps should be made closer. It should be borne in mind however that there are many other things which will cause the engine to miss and act like ignition trouble, viz.: carbureter being out of adjustment, leaky valves, incorrect valve timing, air leaks in intake manifold or around valve stem, engine not oiling properly, lack of compression, etc.

To set ignition: Turn fly-wheel until piston of No. 1 cylinder is at top of compression stroke. Then turn ¼ turn more until marks on fly-wheel (U. D. C. 1 & 6) are opposite reference mark on base of rear cylinder. At this point, turn armature shaft (ignition timer is connected to it) until cam on interrupter, is just starting to break. Put lever in full retard position.

To check point of firing.—Open cylinder pet cocks, retard spark control lever, turn on ignition switch, and notice that the ammeter shows a discharge. Then while one person turns the engine over very slowly with the hand crank, a second person can watch the ammeter. The instant at which the ammeter pointer starts to return to zero, is the time at which the spark occurs. At this instant one of the U. D. C. marks on the fly wheel, should be from 1 to 1½ inches past the dead center reference point. Firing order is 1, 4, 2, 6, 3, 5.

Haynes Electric System (per diagram below).

Haynes car uses the Leece-Neville starter and generator system. A two-unit system.

Starting motor drives the crank shaft in front, by a chain and an over running clutch. Starter is mounted on the left side.

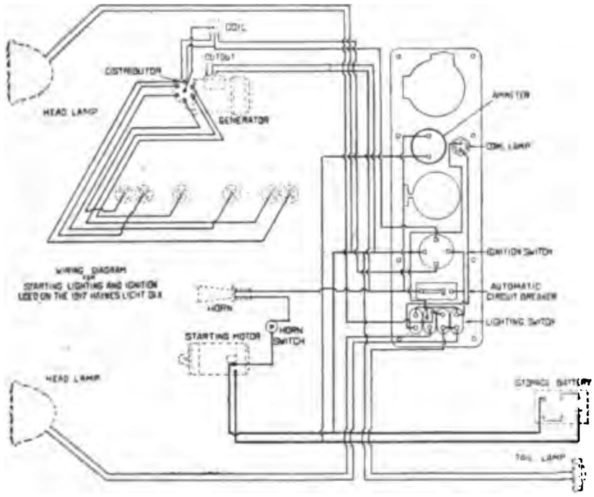
Generator—driven by gears from crank shaft of engine and is mounted on right side. A circuit-breaker or cut-out is mounted on generator.

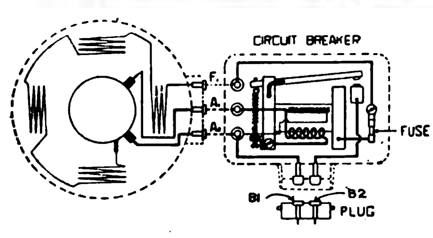
Regulation—by third brush. **Ignition**—on the Haynes "12-40" and "12-41" is Delco. On the "6-37" and "6-36" Remy is used. The distributor and timer are mounted on the generator.

To time the ignition: spark occurs in cylinder No. 1 when mark "IN—CL" (inlet, closes) on fly wheel, comes under pointer—at end of compression stroke and spark lever fully retarded. This causes spark to occur ¾ inch past dead center, as measured on fly wheel. See index for Delco and Remy coil and battery ignition system for further detailed description.

Addresses of Manufacturers of Electric Systems.

Adams & Westlake Co., Chicago, Ill.
Adams-Bagnall Electric Co., Cleveland, Ohio.
"Apelco"—C. F. Splitdorf, Newark, New Jersey.
"Bendix"—Eclipse-Bendix Mfg. Co., Elmira, N. Y.
Electric "Auto-Lite" Co., Toledo, Ohio.
Allis-Chalmers Co., Norwood, Ohio.
Bosch Magneto Co., 223, W. 46 St., N. Y.
Bijur Electric Co., Hoboken, N. J.
Briggs Magneto Co., Elkhart, Ind.
"Dixie"—C. F. Splitdorf Co., Newark, N. J.
Cutler Hammer Co., Milwaukee, Wis.
Detroit Starter Co., Detroit, Mich.
"Disco" Electric Starter Co., Detroit, Mich.
"Dyneto" Electric Co., Syracuse, N. Y.
"Delco"—Dayton Electrical Laboratories, Dayton, Ohio.
Eisemann Magneto Co., New York City.
Gray and Davis, Amesbury, Mass.
Heinze, John O., Springfield, Ohio.
Leece-Neville Co., Cleveland, Ohio.
"North-East" Electric Co., Rochester, N. Y.
"Owen Magnetic;" R. & L. Baker Co., Cleveland, Ohio. Gen'l Electric Co., Fort Wayne, Ind.
"Remy" Electric Co., Anderson, Ind.
"Rushmore"—Bosch Magneto Co. (see above).
"Simms-Huff" Co., East Orange, N. J.
Splitdorf Co., Newark, N. J.
"U. S. L."—United States Light and Heating Corp., Niagara Falls, N. Y.
"Westinghouse" Electric Mfg. Co., Pittsburg, Penna.
"Wagner" Electric Co., St. Louis, Mo.
"Ward-Leonard" Electric Co., Bronxville, N. Y.





Wiring diagram of the Haynes.

CHART NO. 181D—Reo Electric System—continued. **The Haynes—Leece-Neville Starter and Generator, Remy Ignition** (also see chart 169).

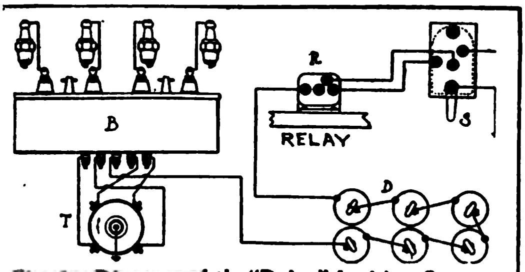


Fig. 1. Diagram of the "Delco" Ignition System

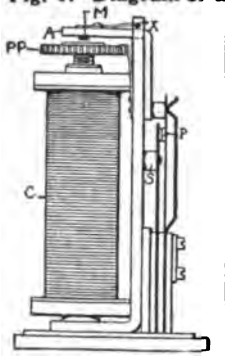


Fig. 2. The Controlling Relay.

The Delco "relay" ignition system consists of: (1) a coil box containing four non-vibrating high tension coils (B); (2) a relay (R) used in the circuit of the commutator or timer; (3) switch (S); timer (T).

The principle of this system is similar to the master vibrator system explained in chart 110, and is used in connection with the old style commutator or a timer.

The master vibrator in this instance is called the controlling relay. The ignition or controlling relay will be explained as follows:

This relay is for the purpose of breaking the primary circuit and thereby producing a spark from the secondary windings of the induction coil.. It takes the place of the four vibrators on an ordinary coil unit, as it acts, for each coil in turn as the commutator makes connection. In this way, it replaces what is commonly known as a master vibrator as explained in chart 110. It differs from the ordinary vibrator, however, in that it uses but one spark for each contact of the commutator.

But in starting, when the button at the top of the switch is pushed in, it opens the auxiliary or holding coil and permits the armature (A) to vibrate the same as any vibrator, **sending a shower of sparks to the cylinder for starting.** This is one of the features of this system. After engine starts a "single" spark is supplied.

Operation of relay. C is the magnet coil, composed of two windings; one heavy winding through which the primary circuit passes when the timer makes contact, thus drawing down the armature A, and opens contact P. This contact opens the circuit and the armature would again return to its first position, making contact and breaking it again as an ordinary vibrator if it were not for a second fine winding, wound on the same coil, but shunted around P. The current flowing through this holds the armature A against pole piece PP until the timer slips off contact, when this auxiliary circuit is opened, thus releasing the armature and allowing the platinum iridium contacts P to come together and be ready to break the circuit when the timer makes the next contact.

A hard rubber spacing support holds the lower contact spring in a definite position. The hard rubber insulating stud on the armature pushes the center spring out and opens the contacts "P" when the armature "A" is drawn down against the pole piece "PP."

PP is a pole piece which screws in or out as desired by means of a ratchet. This is the only adjustment on the entire system and is only used to get the proper opening of the contacts P.

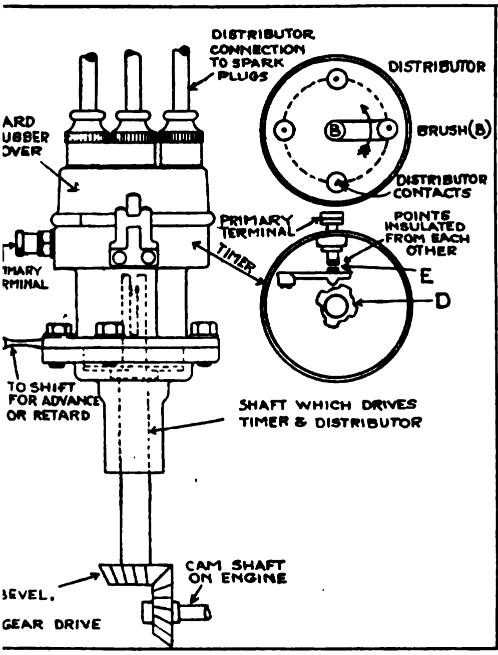

DISTRIBUTOR CONNECTION TO SPARK PLUGS
DISTRIBUTOR
ARD UBBER OVER
BRUSH(B)
B
DISTRIBUTOR CONTACTS
PRIMARY TERMINAL
POINTS INSULATED FROM EACH OTHER
TIMER
E
D
IMARY RMINAL
TO SHIFT FOR ADVANCE OR RETARD
SHAFT WHICH DRIVES TIMER & DISTRIBUTOR
CAM SHAFT ON ENGINE
BEVEL.
GEAR DRIVE

Fig. 3. The distributor and timer arranged in this manner dispenses with the multiple coil, only one non-vibrating coil is now necessary. The relay is not shown with this system. This was the next improved Delco ignition system.

Note diagram; when timer makes contact at E and breaks, the distributor brush (B) makes contact also. Above is an **open circuit** type timer.

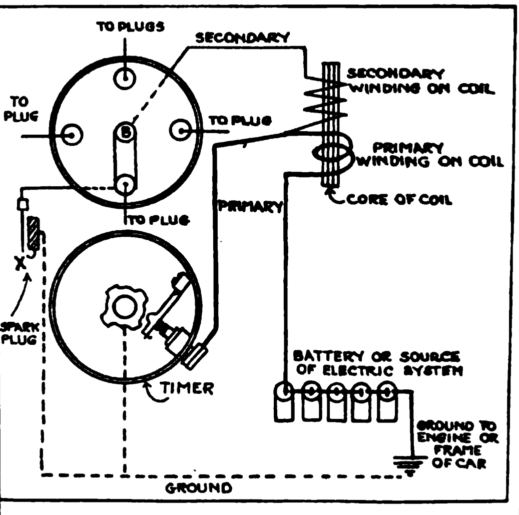


Fig. 4. A wiring diagram of fig. 3. The distributor and timer principle showing how the two are combined in one unit and driven from one shaft. A later development is shown in chart 184.

The timer cam (D) and distributor brush (B) are driven at engine camshaft speed. If engine crankshaft turned 720° or two revolutions, the timer-distributor shaft would revolve one-half the speed or 360°, or one revolution. Note on a four cylinder engine ignition system, there are 4 lobes on cam (D) and 4 points on distributor.

On a **magneto**, as explained on page 295, there are usually 2 lobes on cam, therefore on a four cylinder engine the magneto armature would revolve at engine crankshaft speed.

ART NO. 183—Delco Ignition System. The Relay System: one of the first Delco Ignition Systems. **The next Improved Ignition System was the Delco Distributor and Open Circuit Timer System**, figs. 3 and 4. The later improvement is the system shown on pages 377, 378.

INSTRUCTION No. 28-A.

†DELCO IGNITION SYSTEM: Early Form of Relay System. Distributor and Timer Development. Automatic Advance of Spark. The Modern Delco Ignition. Circuit Breaker. Resistance Unit.

We will not attempt to show all of the Delco systems, but will first explain the original Delco ignition system, then the different ''regulation'' systems used with the Delco generator.

Delco ''Relay'' Ignition.

In order to note the development of the Delco ignition systems, it will be necessary to start at the beginning, therefore we will briefly describe the Delco relay ignition system which is similar in a manner to the master vibrator, except a ''single'' spark is used to run on instead of a ''succession'' of sparks, although a succession of sparks are given to start on.

This relay system was one of the early forms of ignition used for automobile work before the development of the present ''distributor and timer'' system now used so extensively.

This Delco ''relay'' system is still used on marine engines and many four cylinder engines using the old style commutator and vibrating coil. For example, suppose you had a four cylinder engine with four vibrator coils and commutator, then you could better this ignition system by using the relay to take the place of the vibrators. The same timer would be employed. A diagram of this system is shown in chart 183.

Delco Distributor and Timer Development.

The old style commutator faults are explained on page 242. This device was usually placed in front of the engine and run from the end of the cam shaft, just as the principle is now employed on the Ford car. There are many objections to this old style commutator and vibrating coil system, some of the objections are the current consumption, lag in spark timing, sticking vibrator points and the constant moving of wires in advancing and retarding the spark, by shifting the commutator and last but not least, the great amount of wiring necessary.

To overcome these objections the commutator was arranged as a ''timer'' so it would give a single spark instead of a succession of sparks, see fig. 2, page 242. The several coils were dispensed with and one non-vibrating coil was used instead. To accomplish this, the timer and a distributor were combined and operated from cam shaft. This principle is explained on page 230, but in this instance, a ''timer'' making a single contact, is used instead of a commutator as on page 230. A diagram illustrating this timer and distributor development is shown in chart 183 and page 378.

A Later Delco Ignition.

Is the system illustrated in chart 184. This system combines the distributor and timer, but instead of the spark being advanced by hand it is advanced *automatically. The distributor and timer, together with the ignition coil, spark plugs and wiring constitute the ignition system. The source of supply can be from storage battery, dry cells or generator.

The Delco timer is made in two types; **open and closed circuit type**—see page 378.

Parts of the Delco Ignition System.

The combination switch (fig. 5) is for the purpose of controlling the lights, ignition and the circuit between the generator and the storage battery. A later type page 378.

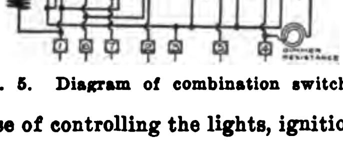


Fig. 5. Diagram of combination switch.

The button M controls both the ignition and the circuit between the generator and storage battery.

The button B controls ignition current from dry cells. (now eliminated).

This is shown on the circuit diagram, fig. 2 chart 184. The button next to (B) controls the cowl and tail lights. The next button controls the head lights. The button on the right controls the dimmer.

---

*An automatic principle is explained on page 248, although the construction is different in chart 117, the principle or idea will be made clear by a study of same. The Delco Co. also produce the non-automatic system, which is used on small four cylinder cars. Dayton Engineering Laboratories, Dayton, Ohio is address of the manufacturers.

†See charts 229 to 234, ''Specifications of Leading Cars'' for those using the Delco system.

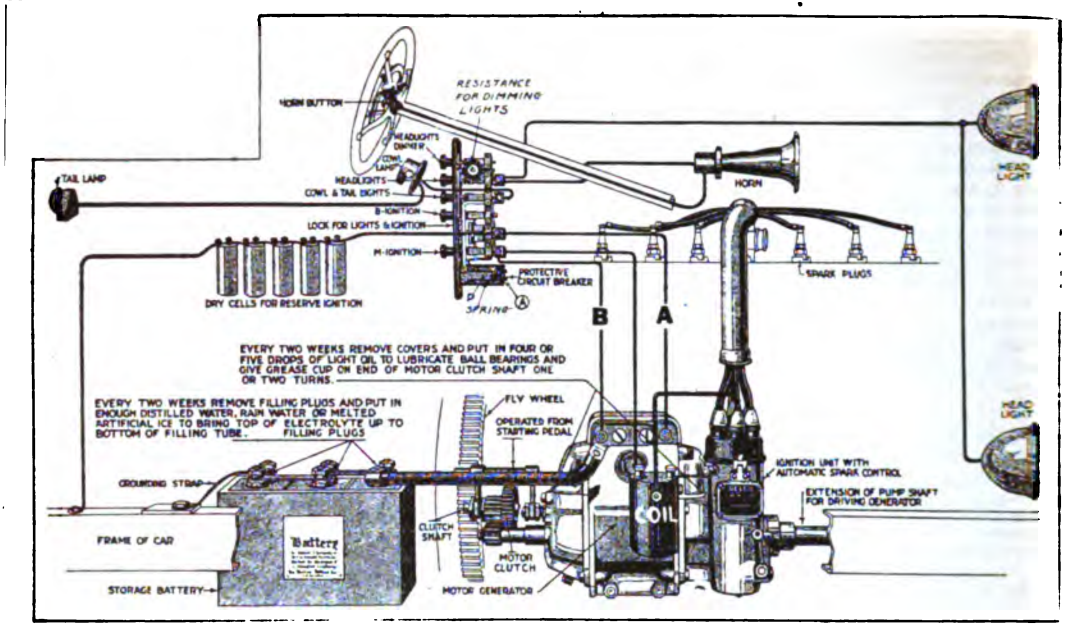

HORN BUTTON
RESISTANCE FOR DIMMING LIGHTS
HEADLIGHTS DIMMER
COWL LAMP
TAIL LAMP
HEADLIGHTS
COWL & TAIL LIGHTS
B-IGNITION
LOCK FOR LIGHTS & IGNITION
M-IGNITION
PROTECTIVE CIRCUIT BREAKER
D
SPRING
A
DRY CELLS FOR RESERVE IGNITION
HORN
SPARK PLUGS
HEAD LIGHT
HEAD LIGHT
B
A
EVERY TWO WEEKS REMOVE COVERS AND PUT IN FOUR OR FIVE DROPS OF LIGHT OIL TO LUBRICATE BALL BEARINGS AND GIVE GREASE CUP ON END OF MOTOR CLUTCH SHAFT ONE OR TWO TURNS.
EVERY TWO WEEKS REMOVE FILLING PLUGS AND PUT IN ENOUGH DISTILLED WATER, RAIN WATER OR MELTED ARTIFICIAL ICE TO BRING TOP OF ELECTROLYTE UP TO BOTTOM OF FILLING TUBE.
FILLING PLUGS
FLY WHEEL
OPERATED FROM STARTING PEDAL
GROUNDING STRAP
FRAME OF CAR
Battery
STORAGE BATTERY
CLUTCH SHAFT
MOTOR CLUTCH
MOTOR GENERATOR
COIL
IGNITION UNIT WITH AUTOMATIC SPARK CONTROL
EXTENSION OF PUMP SHAFT FOR DRIVING GENERATOR

Fig. 1. Illustrating the Delco ignition system. The **distributor** and **timer** are **mounted** on the side of the motor-generator. **The timer** and distributor shaft is driven from the pump shaft, which is driven by gear from crankshaft. This distributor and timer could be mounted separate from the motor-generator. **The ignition** coil (see fig. 4, page 378), in this instance is mounted on the distributor, it could also be mounted separate on the dash or elsewhere.

When either the ignition switch M or B is pulled out, on the combination switch it closes the circuit between the generator and the storage battery at the contact (X) below, and starts the armature of the generator turning over slowly so that the gears can be meshed. In other words, the generator acts, for the time being as a motor.

The (M) button on switch closes the ignition circuit at (X1).

***The (B) button** closes the dry cell ignition circuit at (X2).

"M" is intended to mean "magneto" side for ignition but in reality the source of electric supply is not from magneto at all. The current for ignition is usually given by the storage battery to start with. After engine is started, the generator (not magneto) supplies current, after certain speed (see pages 244 and 341, why called "magneto ignition")

The letter "M" was not intended by Delco to mean "magneto." It was intended for the car driver to use this system as he formerly used the magneto system.

If button "B" is pulled out, note the "dry cells" are used for ignition. The dry cells are seldom used except for auxiliary or emergency.

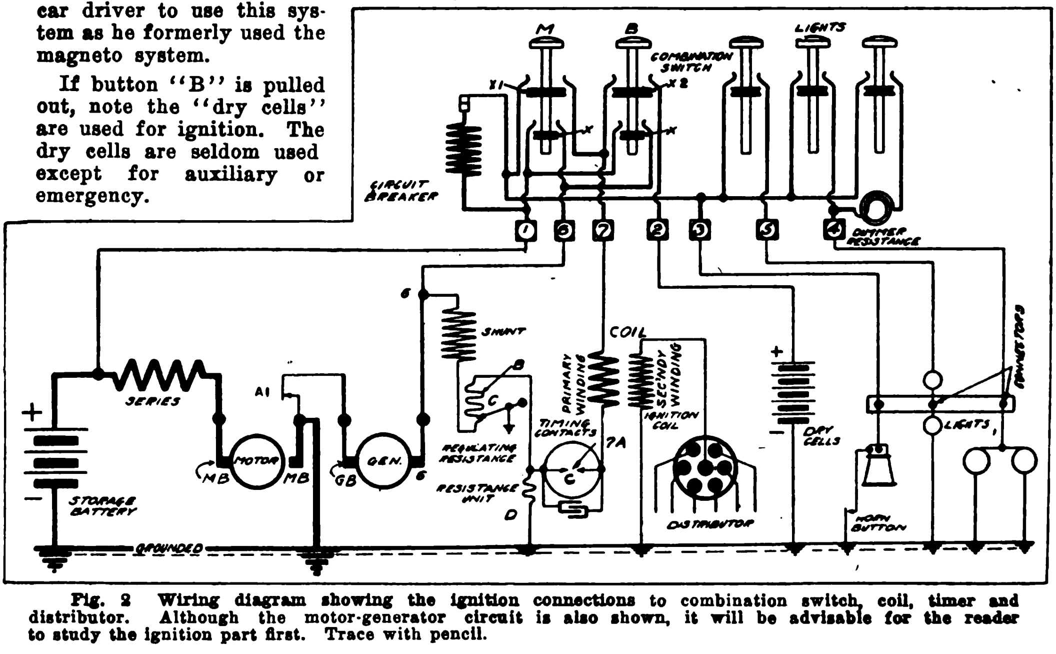


Fig. 2 Wiring diagram showing the ignition connections to combination switch, coil, timer and distributor. Although the motor-generator circuit is also shown, it will be advisable for the reader to study the ignition part first. Trace with pencil.

HART NO. 184—The Delco Ignition System with Automatic Control of Spark Advance. See ages 377 and 378 for description of timer, distributor and coil, etc., and chart 188, for description f the automatic advance mechanism.

*On the latter Delco ignition systems (pages 377 and 378) the "B" switch has been eliminated

Delco Circuit Breaker.

The circuit breaker is mounted on the combination switch as shown in fig. 1, chart 184. This unit is a protective device, which takes the place of a fuse block and fuses. It prevents the discharging of the battery or damage to the wiring to the lamps, horn, or ignition, in case any of the wires leading to these parts become "grounded." As long as the lamps, horn and ignition are using the normal amount of current the circuit breaker is not affected. But in the event of any of the wires becoming grounded, an abnormally heavy current is conducted through the circuit breaker, thus producing a strong magnetism, which attracts the pole piece and opens the contact. This cuts off the flow of current which allows the contacts to close again and the operation is repeated, causing the circuit breaker to pass an intermittent current and give forth a vibrating sound.

It requires 25 amperes to start the circuit breaker vibrating, but once vibrating, a current of three to five amperes will cause it to continue to operate.

In case the circuit breaker vibrates repeatedly, do not attempt to increase the tension of the springs, as the vibration is an indication of a ground in the system. Remove the ground and the vibration will stop.

Circuit Breaker Troubles.

If the circuit breaker indicates a grounded wire, the cover of the junction box on the dash should be removed, and the line which is grounded should be opened at the terminal on the junction block. If the circuit breaker stops vibrating when this is done, the ground must be in the line after it leaves the junction box. If it continues to vibrate, however, the ground is in the switch or ignition circuits.

In case the circuit breaker continues to vibrate when all buttons on the combination switch are depressed, the trouble is almost sure to be in the horn or its connections.

†The Ammeter.

Purpose: The ammeter on the right side of the combination switch (page 388, 378), is to indicate the current that is going to or coming from the storage battery, with the exception of the cranking current. When the engine is not running and current is being used for lights, the ammeter shows the amount of current that is being used, and the ammeter hand points to the **discharge** side, as the current is being discharged from the battery.

When the engine is running above generating speeds, and no current is being used for lights or horn, the ammeter will show **charge.** This is the amount of current that is being charged into the battery. If current is being used for lights, ignition and horn, in excess of the amount that is being generated, the ammeter will show a **discharge,** as the excess current must be discharged from the battery, but at all ordinary speeds the ammeter will read **charge.**

The approximate charging rate for different car speeds when no current is being used for lights or horn, is given in the curve on page 390.

Location. The ammeter would be placed in the line from connection (1), fig. 2, chart 184—to the (+) or positive terminal of battery. The ammeter is not shown connected up in this drawing, but by referring to the upper illustration on page 388 and 391 the location is clearly shown.

*Delco Distributor and Timer.

The distributor and timer, together with the ignition coil, spark plugs and wiring constitute the ignition system.

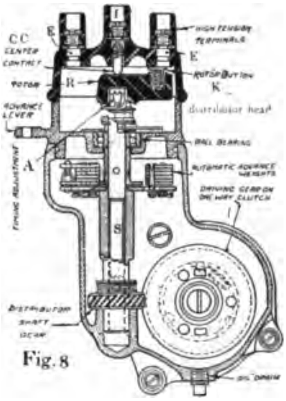


Fig. 8—Illustrates the modern Delco distributor and timer. Note the distributor is above the timer—Buick six as an example.

The distributor and timer shaft (S) is driven by a gear, shown to the right, which is driven by an extension of the pump shaft.

The pump shaft, although it revolves 1½ times crank shaft speed, the vertical distributor and timer shaft (S) is driven at **one-half crank shaft speed.**

Although there is a "clutch" in the driving gear which operates gear on distributor shaft, both are driven at a fixed speed by pump shaft. To understand this, see "generator clutch," page 386.

The distribution of the high tension or secondary current from "rotor-button" (K), fig. 8, to spark plug terminals (E) is **similar** to other systems as Atwater-Kent, Connecticut and others, pages 248, 254, 245.

Distributor rotor (R), fig. 8 distributes the high tension current from the center of distributor (CC), to the spark plug terminals (E). The high tension current is brought from coil to distributor center at top (1), thence carried through (CC), through rotor (R) to spark plug terminals (E). Rotor button (K) should be kept clean.

Distributor-head if removed, must be put back in proper position, otherwise the rotor brush (K) will not be in correct contact with spark plug terminal (E) at the time the spark occurs. Lubrication of this device, see page 397. Distributor head can be removed for cleaning.

*Automatic Advance of Spark.

Advance and retard is obtained by shifting by hand that part of mechanism as shown attached to the "advance lever" fig. 8, in addition to the automatic advance.

An explanation of the automatic advance of spark and the advantages of same are given on pages 246, 249, 807 and 248.

Why Hand Control Also.

The reason is explained on pages 246 and 249, see also page 307.

**Position of Spark Lever.

With the spark lever set at the running position, which is about ⅛ way down (Buick, page 497 as example), the automatic feature of the timer given the proper spark for all speeds; except a wide open throttle at low speed, at which time spark should be slightly retarded.

---

*All Delco systems are not automatic—see pages 394 and 395. †See also page 415.

****When the ignition is too far advanced,** it causes loss of power and a knocking, due to too early ignition. **When ignition is too late or retarded** there is a loss of power (which is usually not noticed excepting by an experienced driver or one very familiar with the car) and heating of the engine and excessive consumption of fuel is the result.

Delco Timer.

Also termed "interrupter," or contact breaker"* is mounted directly under the distributor and operated from the same shaft which drives the distributor—see fig. 8.

The governor advances the cam as the speed increases. By referring to page 248 the governor principle will be made clear, although construction may vary, the purpose or principle is the same.

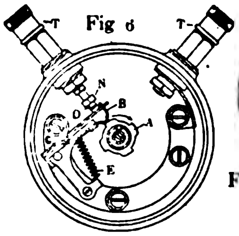


Fig 6

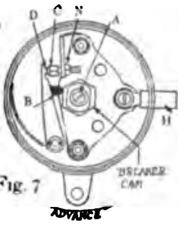


Fig. 7

***Delco timers are made both open and closed-circuit principle.** The latter being used most.

Fig. 6.—Open-circuit type; D—stationary contact; **B—movable** spring blade with other contact—both insulated; **A**—cam which raises (B) and **closes** contact with (D); **T**—are primary terminals (one is sometimes grounded).

Fig. 7.—Closed-circuit type; D and **C** are normally closed; movement of projections on breaker cam **opens** the contact (DC); **H**—is insulated terminal from primary coil winding, connected with point (C); **D**—is arm with other contact point and is grounded (on some of the Delco timers this is just the reverse); **B**—projection on arm (D) which is raised or lowered by lobes on cam.

As a matter of distinguishing the difference, suppose we term fig. 6 a **timer** and fig. 7 an **interrupter**—see page 225.

Adjusting Delco Contact Points.

To adjust the closed circuit interrupter points, loosen the lock nut (N) and raise or lower screw (C), fig. 7. To do this crank engine by hand, until (B) is on top of cam lobe or projection. The space should then be adjusted to .018 or .020 inch. (see also pages 132 and 245.)

To adjust the open circuit timer points, the breaker arm (B), should be **off** the cam lobe A, fig. 6.

To Time Delco Ignition.

See instructions given on pages 132 and 729 (Cadillac) and pages 390 and 245.

Spark Plug Gap

is about .025. **If gaps are too wide,** missing will occur when accelerating at very low speeds and hard pulls; **if too close** will miss at idling and high speeds.

Delco Ignition Coil

Is a regular double-wound high tension coil without a vibrator, per fig. 4, page 245. It is usually round and is sometimes mounted to the side of the motor-generator, per page 376. It is also termed a **transformer coil.**

A condenser is incorporated in it, per page 245, fig. 4. All high tension coils must have condensers.

An ignition resistance unit is mounted on rear end of coil, sometimes it is mounted on timer, per page 392, fig. 37.

Primary Current.

The primary current is supplied through the combination switch and resistance unit on the coil, through the primary winding, to the interrupter contacts. **This is plainly shown on the circuit diagram, chart 184.**

It is the **interrupting** of this primary current by the timer contacts, together with the action of the condenser, which causes rapid demagnetization of the iron core of the coil that **induces** the high tension current in the secondary winding.

Secondary.

Secondary winding; one end terminates at the high tension terminal midway of coil, (see fig. 4, page 245)—thence conducted to distributor at point (I), fig. 8, page 377.

Condenser

principle is explained on page 228. A defective condenser will cause excess sparking at contact points and missing at low speeds. (see page 245.)

Ignition Resistance Unit.

The ignition resistance unit which is shown on the coil in fig. 4, page 245, is for the purpose of obtaining a more nearly uniform current through the primary winding of the ignition coil, at the time the breaker points open. (see also page 246.)

It consists of a number of turns of iron wire, the resistance of which is considerably more than the resistance of the primary winding of the ignition coil. **If the ignition resistance unit was not in the circuit and the coil was so constructed to give the proper spark at high speeds, the primary current at low speeds would be several times its normal value with serious results to the timer contact.** This is evident from the fact that the primary current is limited by the resistance of the coil and resistance unit and by the **impedence** of the coil.

(Impedence is the choking effect which opposes any alternating or pulsating current magnetizing the iron core.) The impedence increases as the speed of pulsations increase. At low speeds resistance of the unit increases, due to the slight increase of current heating the resistance wire.

Delco Combination Switch.

The Delco switch used on the Buick-six is shown below. Note "B" switch, referred to on page 385 has been eliminated.

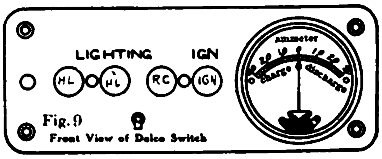


Fig. 9

Front View of Delco Switch

HL—headlight switch; X-HL—auxiliary head lights; RC—rear and cowl or instrument lights; IGN—ignition switch which controls the ignition circuit and also closes the circuit between generator and storage battery.

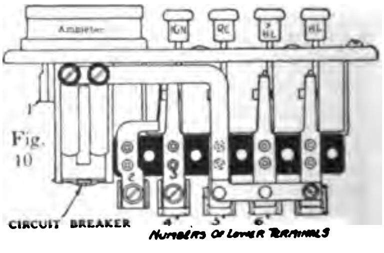


Fig. 10

View showing terminals of Delco combination switch.

Note—On above ammeter the discharge side is to the right. The meter on page 415 discharge is to the left—this varies on different systems.

*Whenever the spring (which is always present on breaker arm) forces the **arm against the cam,** it is an "open circuit" type and when spring forces contact parts together, it is of the "closed circuit" type.

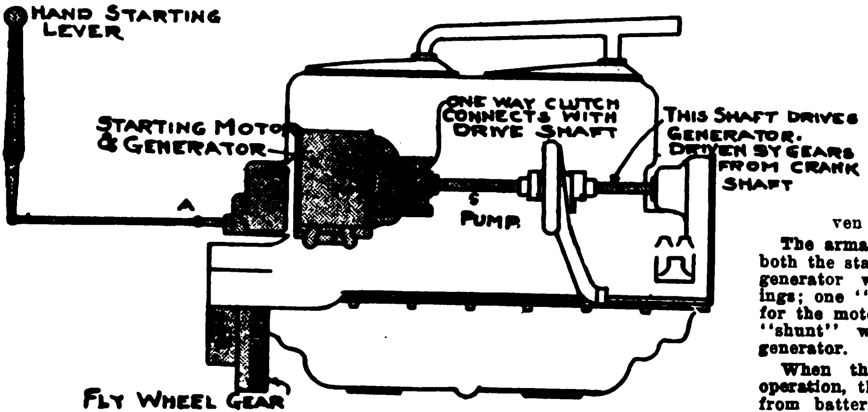

HAND STARTING LEVER
STARTING MOTOR & GENERATOR
A
ONE WAY CLUTCH CONNECTS WITH DRIVE SHAFT
PUMP
THIS SHAFT DRIVES GENERATOR. DRIVEN BY GEARS FROM CRANK SHAFT
FLY WHEEL GEAR

Fig. 1. The mounting of the 1914 Delco motor-generator is similar to the later models.

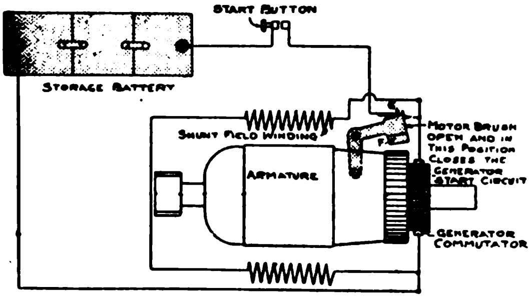


Fig. 2. When starting, push "start button," this sends current from the battery to the generator (not motor) armature, through the field and it revolves slowly. Note: Motor brush is up and makes contact at G for the generator.

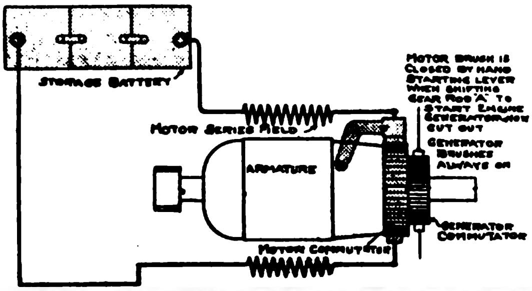

STORAGE BATTERY
MOTOR SERIES FIELD
ARMATURE
MOTOR BRUSH IS CLOSED BY HAND STARTING LEVER WHEN SHIFTING GEAR ROD "A" TO START ENGINE GENERATOR NOW CUT OUT
GENERATOR BRUSHES ALWAYS ON
GENERATOR COMMUTATOR
MOTOR COMMUTATOR

Fig. 3. The motor brush is now down and starting motor is working. Generator is cut out.

The 1914 Cadillac and 1914 Hudson "6-40," Delco motor-generator is located along side of the engine driven by pump shaft.

The armature is used for both the starting motor and generator with two windings; one "series" winding for the motor, fig. 3, and a "shunt" winding for the generator.

When the motor is in operation, the current flows from battery to the series winding through the motor brush and commutator.

When the generator is in operation, the motor brush is raised at (F) fig. 2. The generator brushes remain on commutator at all times. The current then flows through the "shunt" winding.

The starting motor drives the flywheel gear through the gears C, D and B (fig. 4). A roller type clutch is provided on the front part of armature shaft, so that the armature is free from the pump shaft which drives the generator.

The armature is driven by connection with pump shaft by engine, after engine is started and starting gears are out of mesh.

A one-way clutch connects the pump shaft with armature shaft to drive generator. This clutch will permit the pump shaft to drive generator, but generator armature when running as a motor cannot drive the shaft (see index "generator clutch" explaining action of a one-way clutch).

Starting Operation.

First: Place ignition switch on battery side. **Next;** depress starting button on dash (see fig. 2). This sends current from the storage battery to the generator (not the motor) and in passing through the generator field shunt winding, and armature winding, the armature slowly revolves.

The purpose in using the generator as a motor is to revolve the armature slowly, so that gears will mesh with flywheel gears when the starting lever throws them in mesh. It must be remembered that the brush on starting motor commutator is not in contact, but being in the position as shown in fig. 2, the generator circuit it closed at G, but not the motor circuit.

Next, after generator armature is revolving slowly, pull back on starting lever.

This causes rod "A" to be pushed forward, causing gear "B" of the starting clutch to mesh with motor pinion "C." Immediately after gears "B" and "C" are meshed, the gear "D" which is integral with "B," meshes with the gear teeth on the fly wheel, and at the same time, the extension of the rod "A" to the bell crank "E" allows the motor brush "F" to travel toward the motor commutator, opening the generator circuit and shunt field at "G" and closing the motor circuit.

The generator would then be cut out and the starting motor is revolving engine through the fly wheel. (fig. 3.)

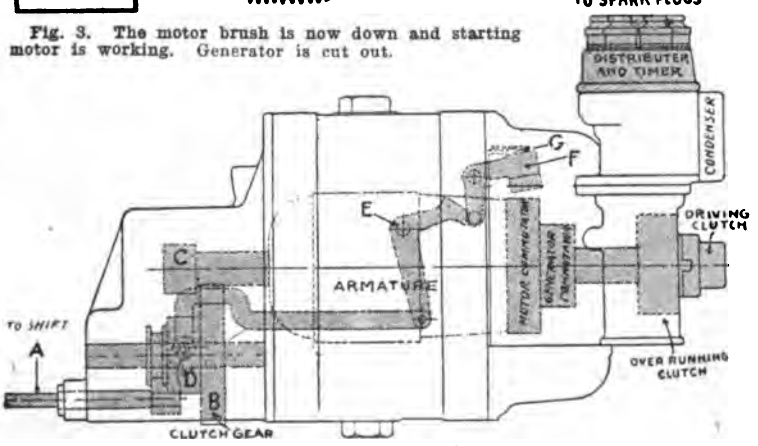
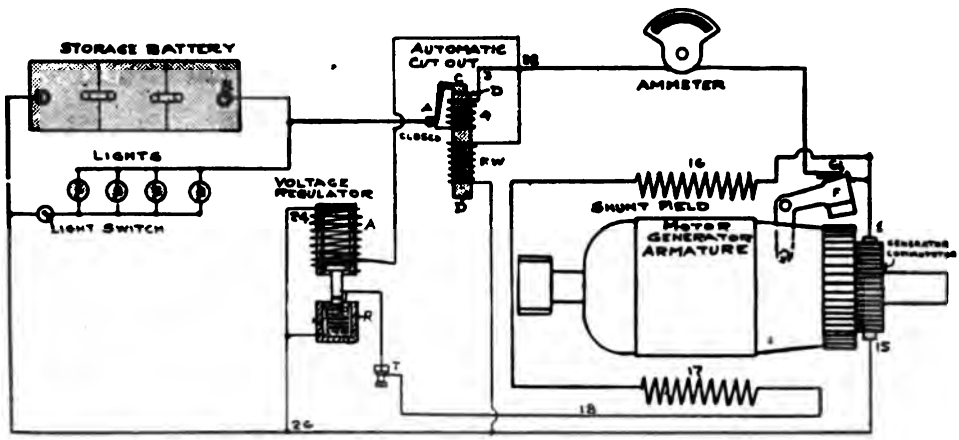


Fig. 4. Phantom view of motor-generator.

CHART NO. 185—The 1914 Delco Starting and Generating System, explaining the first principles of the Delco system and how the one Armature serves for both the Motor and Generator.



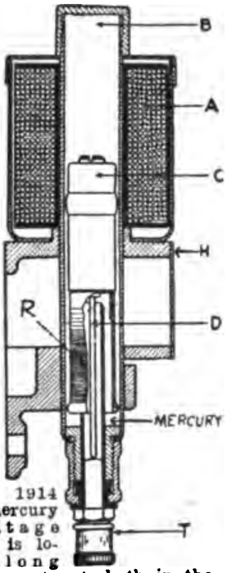


Fig. 2. 1914 Delco mercury type voltage regulator is located along side of the cut out, both in the battery box or on the inside of dash under hood.

Purpose; to control the amount of current flowing from generator to the storage battery. (See chart 168 explaining purpose of regulator.)

Description: A magnet coil (A) surrounds the upper half of the mercury tube (B). Within this mercury tube is a plunger (C) comprising an iron tube with a coil of resistance wire (R), wrapped around the lower portion on top of mica insulation. One end of this coil is attached to the lower end of the tube, the other end being connected to a needle (D) carried in the center of the plunger.

The lower portion of the mercury tube is divided by an insulation tube into two concentric wells, the plunger tube being partly immersed in the outer well, and the needle in the inner well. The space in the mercury tube above the body of the mercury is filled with an especially treated oil, which serves to protect the mercury from oxidization, and to lubricate the plunger. A bracket (H) serves to support the parts described.

Generating Current.

When the starting lever is released, the spring throws the gears out of mesh, and at the same time **raises the brush (F) from the motor** commutator and closes the generator circuit again. The "start" button having been released in the first operation, **the generator is now generating current**, as the engine is running and driving the armature as a generator through pump shaft.

The starting motor has served its purpose and is now cut out of operation, as the brush "F" is away from motor commutator.

The principle of this mercury type of voltage regulator is as follows: The generator, as stated previously, is driven from the pump shaft which is driven by gears in front of engine from crank shaft.

After engine is started and hand starting lever disengages the gears out of flywheel, and motor brush "F" is lifted off of motor commutator, the motor is cut out and the generator is now in action as it must run when engine runs, as the pump shaft is connected with armature through a one-way clutch (see fig. 1, chart 185), which permits the engine to drive armature, but the armature, when revolving as a motor, cannot drive the engine only through the gears to flywheel. This clutch permits the armature to run ahead of the driving shaft during the cranking operation.

The generator now begins to generate current; but until engine is running at a speed which will turn generator armature fast enough to generate a pressure of 6 volts, or required amount to overcome the pressure or voltage of the storage battery, the current will pass from generator commutator 1, to 2, around the fine wire winding of cut out core (D), thence back to the other commutator brush 15. This current will continue to travel in this path until it has sufficient pressure, which is slightly over 6 volts, to magnetize the core (D) so that it will draw the magnet armature of cut out (C) down—when circuit is closed to battery. Battery will then be charged from generator, or generator will also supply current for light. At other times, the storage battery supplies current for lights.

If engine is speeded up, the pressure increases and lights would be burnt out, therefore, the mecury regulator is brought into action.

As the voltage increases with speed, the intensity of the magnetic pull exerted by the magnet coil "A" upon plunger "C" causes the plunger (C) to move up out of the mercury.

Now the current to the shunt field (17) of the generator must follow a path leading into the outer well of mercury, through the resistance coil (R) wound on the plunger tube, to the needle carried at the center of the plunger, into the center well of mercury and out of the regulator.

It will be seen that as the plunger is withdrawn from the mercury, more resistance is thrown into this circuit, due to the fact that the current must pass through a greater length of resistance wire. **This greater resistance in the field of the generator** causes the amount of current flowing to the battery to be gradually reduced as the battery nears a state of complete charge, until finally the plunger is almost completely withdrawn from the mercury, throwing the entire length of resistance coil into the shunt field circuit, thus causing a condition of practical electric balance between the battery and generator, and obviating any possibility of over charging the battery. **As the speed** decreases, the magnetic pull of the core (A) is weaker and plunger "C" assumes a lower position.

The late Delco system does not use the automatic "cut-out" or "mercury type" regulator.

HART NO. 186—The 1914 Delco Generating System. Action of the Mercury Voltage Regulator. his regulator is not now used but shown in order to explain the principle.

INSTRUCTION No. 28-B.

*DELCO ELECTRIC STARTING, GENERATING, LIGHTING AND IGNITION SYSTEM: Generators. Motor Generators. Early System. Regulation Methods; mercury, variable resistance and third brush. Principle and Theory of Delco Systems. Examples Delco Systems: Hudson, Buick, Cole, Oldsmobile, Cadillac. Motoring the Generator. Motor and Generator Clutches. Charging Rate Curve.

Early Delco Electric Systems.

In order that the reader will understand the later Delco systems, it will be necessary to begin with the early models. A study of chart 185 and 186 is advised before proceeding.

One Armature Serves for Motor and Generator.

It is well to note, that Delco employs one armature, but two commutators on their motor-generators in the later Delco systems as well as the early systems. The motor commutator and the generator commutator can be placed both at one end of armature, which is the method employed on the Buick model D-44, also in 1914 model as per charts 185 and 186, or the commutators can be at opposite ends of armatures, as per chart 188.

Windings.

Armature winding. There are two regular "drum" type windings on the armature, one for the generator and one for the motor.

Field windings. There are two windings on the plain two pole (bi-polar) fields; a "series" for the motor and a "shunt" winding for the generator (see chart 187,) with the exception of the types that are regulated by the "reverse series" method, employing a third field winding.

The motor series field winding is wound from strip copper. The **generator shunt** field winding is separated from it entirely. and is brought out to the terminals on one end of the field coil. One of these is connected to the generator brush lead and the other to the bottom of the regulating resistance (B). See chart 187 and 188.

Delco Regulation Methods.

The "mercury" voltage regulator was used on the 1913 and 1914 models of the Delco system, as explained in charts 185 and 186. This regulation system is now seldom used.

***__The "third brush" regulation method, is the popular Delco principle__ now employed and will be explained further on.

The "variable resistance" regulation is also used at the present time on some of the Delco systems. An example of this principle is shown in charts 187, 188, and 188D. The Hudson "six-40," Buick models "38 and 54," Cole "6-50" page 392, used this system. As an example we will use the Hudson "Six-40."

Principle of the Delco "Variable Resistance" Regulation—Hudson "Six-40" as an example.

The object or purpose of "regulation" of the output is explained in instruction twenty-seven, therefore we will not deal with the principle here but will take up the general construction.

The variable resistance regulation is accomplished through a special resistance wire wound on a spool of non-inflammable material and mounted in the distributor housing just back of the condenser as shown at B fig. 3, chart 188.

****By inserting some of this regulating resistance on spool (B) in the shunt field circuit at the higher speeds,** the output is controlled automatically by the lever (C) and the same mechanism that advances the spark. The circuit can be readily understood by referring to the circuit diagram, chart 187, and from this circuit diagram it can be seen that all of this resistance is in the shunt field circuit when the arm C is at the top position; that is, at maximum speed (also see fig. 3, page 384).

The "ignition resistance unit" (D) is grounded through the output resistance and is cut out of the ignition circuit when the arm it at the top position. This increases the intensity of the spark at high speeds. Note however, that it is distinct and separate from the "regulating resistance unit."

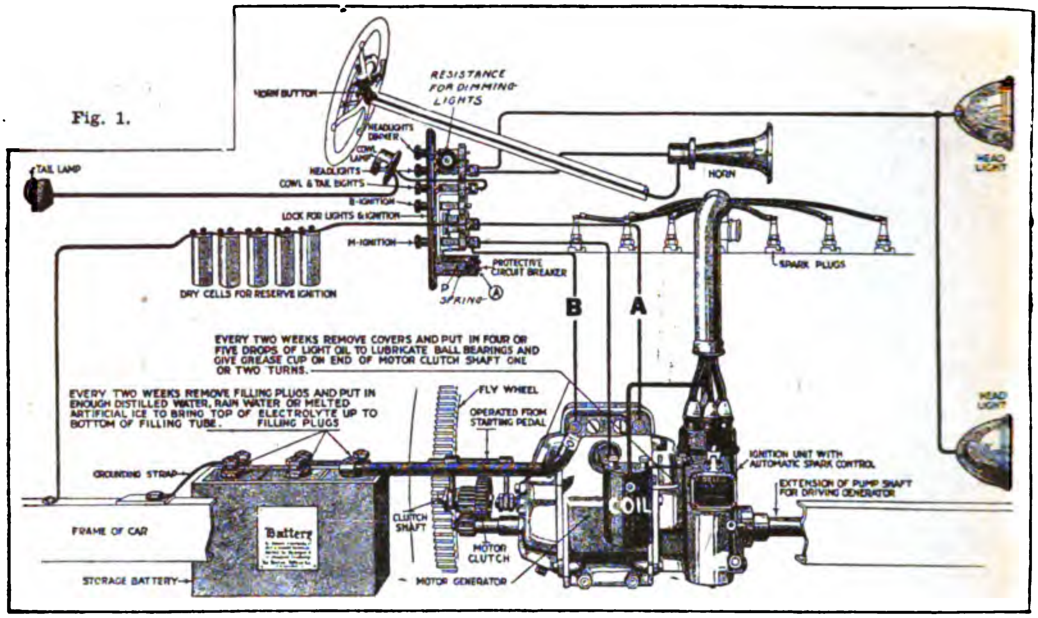
---

*See charts 229 to 232 for users of Delco electric systems.

**See page 387 for different sizes of resistance units to use.

***See also page 370.

Fig. 1.



EVERY TWO WEEKS REMOVE COVERS AND PUT IN FOUR OR FIVE DROPS OF LIGHT OIL TO LUBRICATE BALL BEARINGS AND GIVE GREASE CUP ON END OF MOTOR CLUTCH SHAFT ONE OR TWO TURNS.

EVERY TWO WEEKS REMOVE FILLING PLUGS AND PUT IN ENOUGH DISTILLED WATER, RAIN WATER OR MELTED ARTIFICIAL ICE TO BRING TOP OF ELECTROLYTE UP TO BOTTOM OF FILLING TUBE.

The starting motor and generator, use the same armature. The starting motor is explained in these charts. Therefore we will deal with the generator and winding and the circuits of wiring in this chart.

When the generator is supplying the current, it comes from the forward terminals on the side of the generator through the wire "A" to No. 6 terminal on the switch (see below), and since Nos. 1 and 6 terminals are connected (when either the "B" or "M" button on the switch is pulled out). it can be seen that there will always be current supplied to this switch for the lights, horn and ignition. The excess current flows through the switch wire "B" to the rear terminals on the generator and the heavy lead wire to the battery, thus charging the storage battery.

An ammeter inserted in the "A" line would indicate the amount of current coming from the storage battery to the generator, in case the engine was not running, or the current being generated when the engine is running.

The primary ignition current is an intermittent current—it flows only when the timer contacts are closed. This current can be readily traced on the diagram. A high voltage is induced in the secondary winding of the ignition coil when the flow of primary current at the timer contact is broken. This causes a spark to occur at the plugs when the breaker contacts open.

When the dry battery ignition is being used, the current is supplied in exactly the same manner as though it was coming from the storage battery; the "B" button on the combination switch closing the circuit between terminals No. 1 and No. 6, in order that the generator may be connected to the storage battery for charging purposes.

The regulation of the output of generator in this particular system, is controlled automatically by the lever C (see below and fig. 3, chart 188), which is raised and lowered by the action of the governor which cuts resistance into the shunt field winding at higher speeds; thereby weakening the strength of the fields, consequently the output of generator. This is called "variable resistance" method of regulation.

Fig. 2.

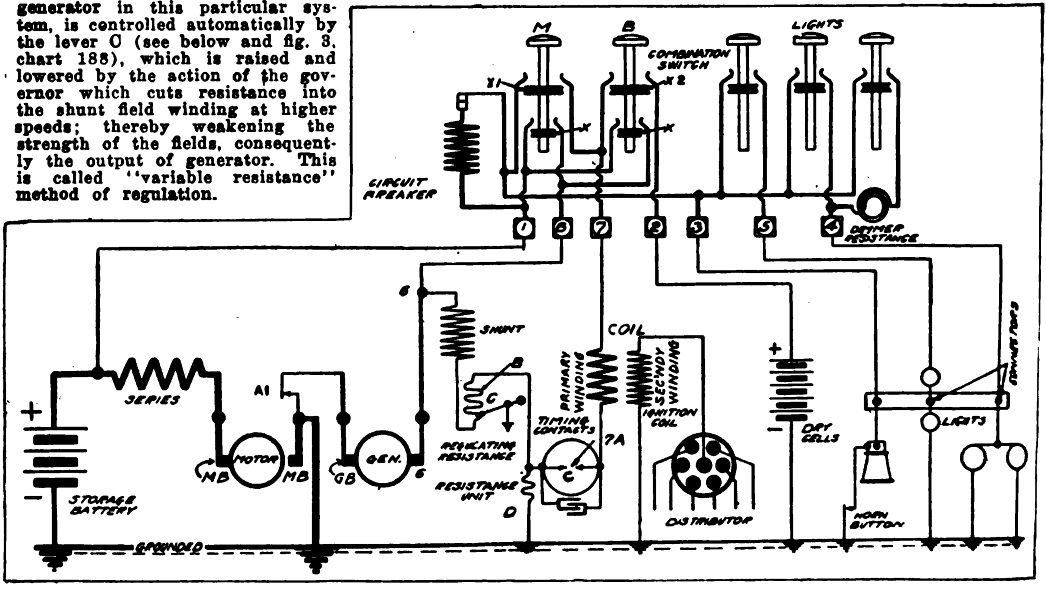


CHART 187—The Delco Electric System with "Variable Resistance Regulation" of Output of Generator and "Automatic Control of Spark" as used on the Hudson "Six-40." A "single-unit" "single wire" system.

The Control of the "Variable" Regulating Resistance—by governor action.

Note the action of the governor which controls the cutting in and out of this resistance. (See fig. 3, chart 188). The spiral gear (SG) is attached to the timer shaft (TS), this gear is operated by the pump shaft independent of the armature shaft. This gear being a part of the clutch which connects with the pump shaft. If distributor was driven from armature shaft the timing would be affected during the starting operation, during which time the armature operates at a different speed than pump shaft. The pump shaft runs at one and one half times crankshaft speed, but the six lobe cam, and the shaft, operate at one half engine crank-shaft speed.

As the timer shaft revolves the governor weights (G) assume a rising position which raises the arm (A), thereby raising the lever (C) which makes contact with the bare resistance wire (B), wound on an insulated spool. The principle is that as the speed of the engine increases the speed of the timer shaft increases and the governor arms (G) raise higher as the speed increases, thereby raising the arm (C) higher.

The higher arm (C) is raised, the more of this resistance wire is thrown into the field circuit, thereby weakening the output and keeping the current from gaining as the charging rate increases at the higher speeds.

The Automatic Advance of Ignition Controlled by Governor Action.

At the same time the timer cam on the end of the timer shaft is automatically "advanced." (As the speed is increased the action of the governor turns the timer cam in the direction of rotation) thereby causing earlier contact.

The ignition system is practically the same Delco principle described in previous instruction.

The resistance unit shown at (D) fig. 3, chart 188, is a coil of resistance wire, the purpose of which was explained in a previous instruction. See page 246.

This ignition resistance unit has connected in parallel with it, the regulating resistance (B), fig. 3, chart 188, see also diagram, chart 187.

When the arm "C," is in the lower position, the resistance of this path greatly exceeds that through the resistance unit, and practically all the ignition current passes through the ignition resistance unit.

But as the arm raises, as at high speed, this resistance is decreased, and when the arm is at the top position the full voltage is applied to the ignition coil.

In the event of the ignition resistance unit (D) being disconnected or burned out, it is impossible to get sufficient current through the regulating resistance, unless the arm "C" is held near the top.

The Automatic "Cut-Out" in this System not Used.

On the early Delco system (chart 186), the "cut-out" served the purpose of disconnecting the generator circuit from the storage battery, when the generator was running at slow speed and generating less than 6 volts. The principle being the same magnetic principle as described previously.

On the system now being explained (chart 187), and later systems, the "cut-out" is eliminated—The ignition buttons "M and B" in a way, takes the place of this cutout. The operation of either button controls the circuit between the generator and the storage battery. Should the engine stop and the ignition button (M or B) remained pulled out, the amount of current that comes from the storage battery is that which is required to operate the generator as a motor when first starting, and is about five amperes.

When the engine is not running, or when it is running below 300 R. P. M. and the circuit between the generator and the storage battery is closed by either the "M" or "B" button on the combination switch, the direction or flow of the current is from the battery to the generator and if the speed is very low indeed, as when throttled down to three miles per hour, the generator will over-run and the clutch will be heard in operation, as before stated.

A warning is given when the ignition button is pulled out or left pulled out (and engine were to stop) by the clicking of the ratchet type of driving clutch (see fig. 16, page 398), with which all these generators are equipped.

When the engine is running below 300 revolutions, then this clicking of ratchet will take place again, because the current from the battery is running back into generator slowly revolving it. This indicates that the generator is not running fast enough to overcome the pressure of battery. The amount of current that flows from the battery back to the generator at this slow engine speed is so small that it is negligible, therefore the automatic "cutout" can be eliminated.

Over 300 revolutions, the generator is running fast enough to overcome the battery pressure.

Single Wire or Grounded System.

The Delco wiring of the different parts are shown in figs. 1 and 2, charts 187. Note the single wire system is used in the illustration—the frame of the car being used to carry the return circuit.

The generator, storage battery, motor, lamps, horn and ignition apparatus each have a connection "grounded" to some part of the frame of the car or engine. The other connections are made with copper wires or cables.

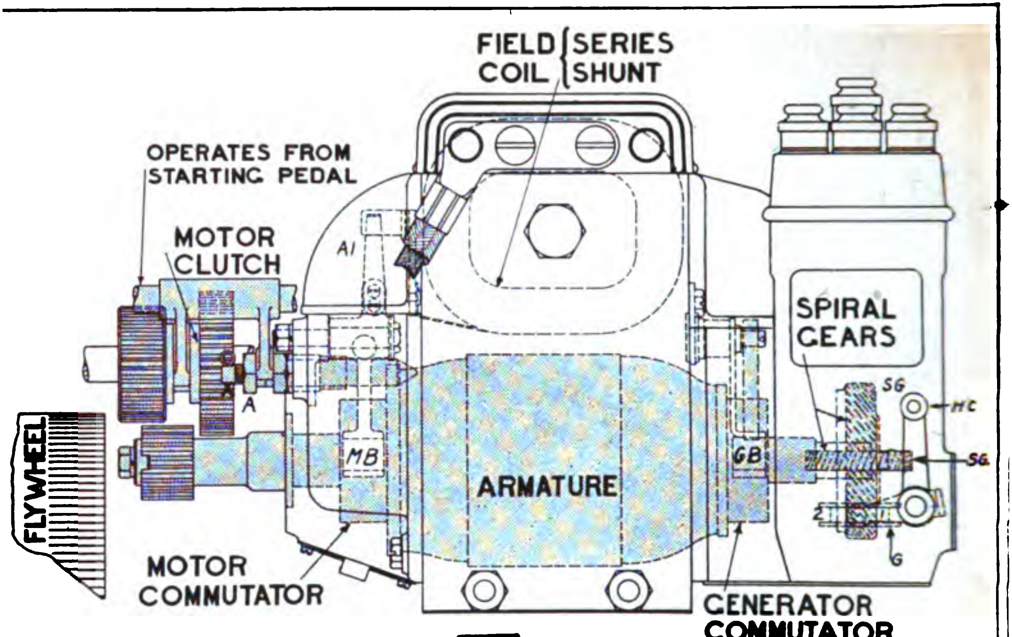


Fig. 1

The armature winding; there are two regular " drum" type windings on the armature. One for the generator and one for the motor. But only one armature. There are two commutators on the No. 1 system, one at each end; one for the generator circuit and one for the motor circuit.

The generator brush (GB), remains on the generator communitator, but the generator circuit (A1, fig. 2), is opened when the motor brush (MB), is in action starting the motor.

The motor brush is raised and lowered to the motor commutator, by the motor brush switch (A). When the engine is started and starting pedal is released, the motor brush switch (rod A), raises the motor brush and opens the motor circuit and closes the circuit to generator at (A1).

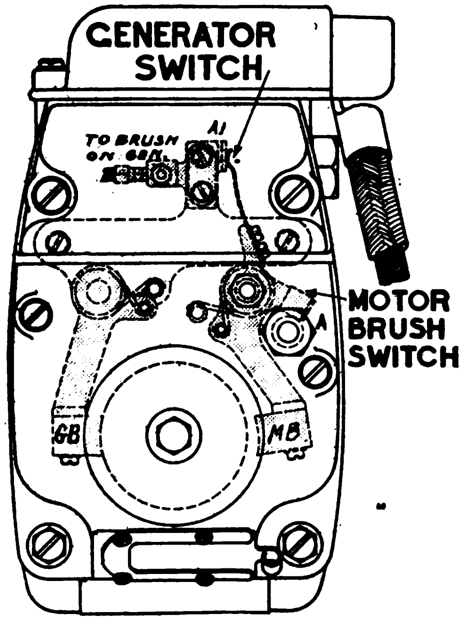


Fig. 2

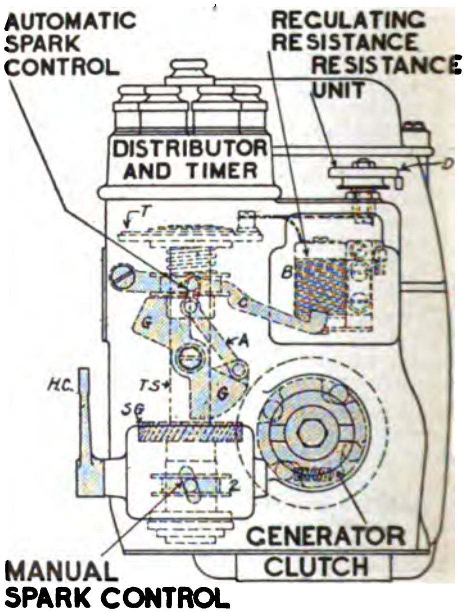


Fig. 3

Generator brush (GB), remains on generator commutator. Generator circuit is opened and closed by action of switch (A1), raising motor brush (MB).

(HC), connects with steering post spark lever and is called the manual control of spark.

(G), Governor on the timer shaft—operates utting in resistance wire at (B), by centrifugal action as speed increases it raises and actuates lever (C), through rod (A). At the same time the timer contact on end of shaft is made to break earlier, thereby advancing time cf ignition. Spiral gear (SG), drives timer shaft from another spiral gear (see fig. 1), on outer shell of generator driving clutch.

ART NO. 188—The Delco Motor-Generator with Automatic Spark Advance and "Variable Resistance Regulation" of Field Current or Output of Generator. (See chart 187 for wiring diagram.) Note commutator on each end of armature.

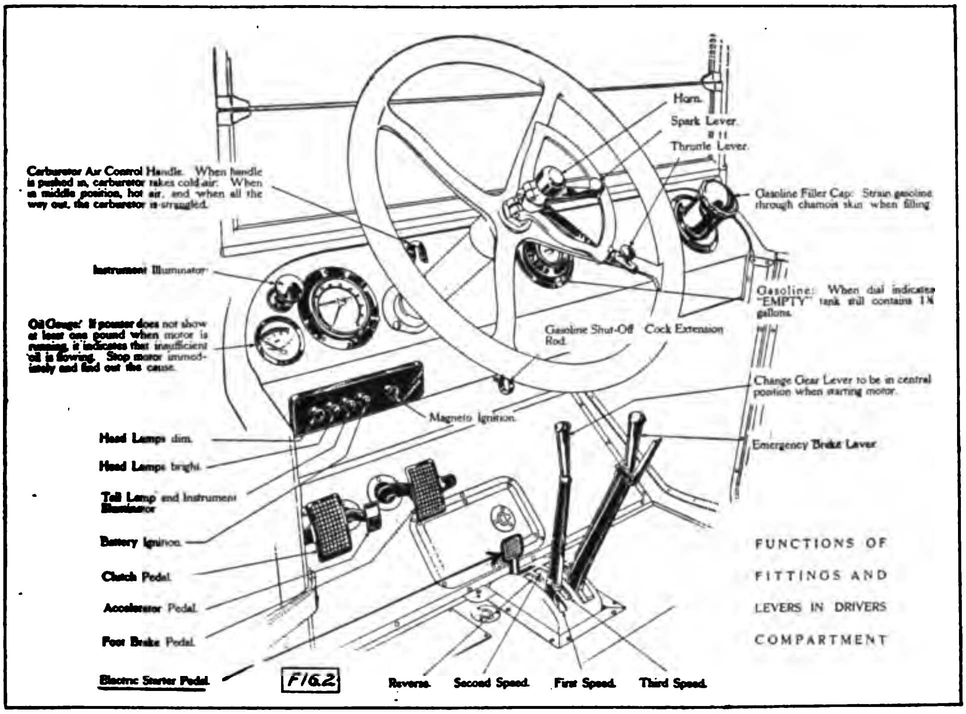

Carburetor Air Control Handle. When handle is pushed in, carburetor takes cold air. When in middle position, hot air, and when all the way out, the carburetor is strangled.
Instrument Illuminator
Oil Gauge: If pointer does not show at least one pound when motor is running, it indicates that insufficient oil is flowing. Stop motor immediately and find out the cause.
Head Lamps dim.
Head Lamps bright.
Tail Lamp and Instrument Illuminator
Battery Ignition.
Clutch Pedal.
Accelerator Pedal.
Foot Brake Pedal.
Electric Starter Pedal.
Horn.
Spark Lever.
Throttle Lever.
Gasoline Filler Cap: Strain gasoline through chamois skin when filling.
Gasoline: When dial indicates "EMPTY" tank still contains 1¼ gallons.
Gasoline Shut-Off Cock Extension Rod.
Change Gear Lever to be in central position when starting motor.
Magneto Ignition.
Emergency Brake Lever
FUNCTIONS OF FITTINGS AND LEVERS IN DRIVERS COMPARTMENT
Reverse.
Second Speed.
First Speed.
Third Speed.

FIG.2

Starting Operation, to Explain Diagram Page 382.

"Hudson" Six-40 as an Example.

(1) **Pull out ignition switch *M or B.** If M, current for ignition is taken from circuit (1), storage battery (page 382). If B, switch is pulled out, ignition is taken from dry cells (2). In both instances the generator circuit is closed at (X), and generator armature (now acting as a slow running motor), turns over slowly so that starting gears (fig. 1, chart 188), can be meshed. See page 399—"motoring the generator."

(2) **Depress "electric starter pedal"** (fig. 2 above); this action lowers motor brush (MB) and **opens** the generator circuit at (A1—fig. 2, page 382)—see figs. 1 and 2, page 384 and note rod (A), which operates this brush (MB) on "motor" commutator, when gear is shifted into fly wheel gear.

(3) **After engine is started**—starting pedal is released—gears are then thrown out of mesh—the motor brush (MB) is raised and generator circuit **closed** at (A1). **Therefore the starting motor is cut out by brush (MB) being raised and generator is in action. The** generator brush (GB) remains on its commutator at all times. The opening **and closing** of its circuit being at (A1).

Note—When either the "M" or "B" button is pulled out and the armature is revolving, a clicking sound will be heard. This is the operation of the generator clutch. This clicking sound will serve as a reminder that the **ignition circuit is closed.** When the engine is stopped or stalled, do not leave either the "M" or "B" button pulled out, as the battery will discharge through the generator.

1918 Hudson Starting Operation.

By referring to page 391, the 1918 electric system is shown. Note there is but one ignition switch (IGN). The dash board is similar except—a different gasoline regulator and air control is used (fig. 3). The gasoline tank is also on the rear (page 204). A Stewart vacuum system is used.

(1) See that the "gasoline feed regulator lever" is in the center position.
(2) See that the gasoline "air control lever" is in the "hot" position.

Note that the gasoline regulator lever should be moved over to the "rich" position to facilitate starting in cold weather. When this is necessary, the air control lever should be moved over to the "choke" position for a moment when cranking, and should be moved back to a position midway between "choke" and "hot" as soon as the engine starts. If this is not done, the engine will draw too rich a mixture. This applies only when the engine is cold.

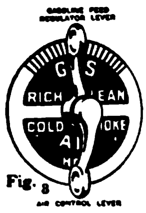


Fig. 3

(3) Have the throttle lever an inch from the bottom of the quadrant and the spark lever about three inches from the top of the quadrant. (In cold weather it may be necessary to open the hand throttle a little farther than in warm weather.)

(4) **Pull out the ignition button** (IGN) on the combination switch **as far as** it will come.

(5) Have the left foot ready to use on the accelerator when the engine starts, and with the right foot press down gently on the starting **pedal.**

(6) After engine starts release starting pedal.

HART NO. 188A—Starting Operation Delco Electric System—on the Hudson "Six-40" **as a xample. Also 1918 Hudson Starting Operation.** *M—on the early Delco system means **ignition** thro-**torage** battery or generator (not magneto); B—through dry cells or an auxiliary battery for starting.

Delco Starting and Generating System Using a "Third Brush" Regulation.

This system is similar to previous Delco system described, except in the "regulation" of current and miner details. We will use this system, to more completely describe the generator and it's functions. The Delco system on the Buick D 54 and D 55 will be used as examples.

*Delco Motor-Generator Principle.

The motor-generator is located on the right side of the engine (chart 188-B).

This consists essentially of a dynamo with two field windings, and two windings on the armature, with two commutators and corresponding sets of brushes, in order that the machine may work both as a starting motor, and as a generator for charging the battery and supplying current for the lights, horn, and ignition.

The ignition apparatus is incorporated in the forward end of the motor-generator. This in no way affects the working of the generator, it being mounted in this manner simply as a convenient and accessible mounting.

The motor-generator has three distinct functions to perform, which are as follows: **1—motoring the generator. 2—cranking the engine. 3—generating electrical energy.**

**"Motoring" the Generator.

"Motoring" the generator means to use the generator armature temporarily as a motor. The purpose of using the generator as a motor is to revolve the armature slowly, so that the gears will mesh with fly wheel gears when starting. If the current was immediately applied to starting motor, it would revolve at full speed immediately. By "motoring the generator" however, the armature revolves slowly until gears are meshed, then the full current is applied to starting motor.

This operation is accomplished when the ignition button on the switch is pulled out. This allows current to come from the storage battery through the ammeter on the combination switch, causing it to show a discharge. The first reading of the meter will be much more than the reading after the armature is turning freely. The current discharging through the ammeter during this operation is the current required to slowly revolve the armature and what is used for the ignition.

Meshing gears. This motoring of the generator is necessary in order that the starting gears may be brought into mesh, and should trouble be experienced in meshing these gears, do not try to force them, simply allow the starting pedal to come back, giving the gears time to change their relative position.

Generator Clutch.

A clicking sound will be heard during the "motoring of the generator." This is caused by the "over-running of the clutch" in the forward end of the generator which is shown in (fig. 1, chart 188-B and fig. 16, page 398).

The purpose of the generator clutch is to allow the armature to revolve at a higher speed than the pump shaft during the cranking operation and permitting the pump shaft to drive the armature when the engine is running on its own power. Spiral teeth are cut on the outer face of this clutch for driving the distributor. This portion of the clutch is connected by an Oldham coupling to the pump shaft. Therefore, its relation to the pump shaft is always the same and **does not throw the ignition out of time during the cranking operation.**

Lubrication of clutch is from the oil that in contained in the front end of the generator which is put in at B (fig. 1, chart 188-B.) This is to receive oil each week sufficient to bring the oil up to the level of the oiler.

Cranking Operation.

The cranking (engine starting) operation, takes place when the starting pedal is fully depressed. The starting pedal brings the motor clutch gears, (fig. 1, chart 188-B) into mesh and withdraws the pin P, (figs. 1 and 2) allowing the motor brush switch to make contact on the motor commutator. At the same time the generator switch breaks contact. This cuts out the generator element during the cranking operation.

As soon as the motor brush makes contact on the commutator, a heavy current from the storage battery flows through the series field winding and the motor winding on the armature. This rotates the armature and performs the cranking operation. The cranking circuit is shown in the heavy lines on the circuit diagram (lower illustration.)

This cranking operation requires a heavy current from the storage battery. If the lights are on during the cranking operation, the heavy discharge from the battery, causes the voltage of the battery to decrease enough to cause the lights to grow dim.

---

*When the word "motor-generator" appears coupled together this indicates they are combined in one unit.

**See page 399 for principle, troubles and tests.

Cranking current. This is noticed especially when the battery is nearly discharged; also will be more apparent with a stiff engine or with a loose or poor connection in the battery circuit or a nearly discharged battery. It is on account of this heavy discharge current that the cranking should not be continued any longer than is necessary, although a fully charged battery will crank the engine for several minutes.

Ammeter readings during cranking operation: During the cranking operation the ammeter will show a discharge. This is the current that is used both in the shunt field winding and the ignition current; the ignition current being an intermittent current of comparatively low frequency, will cause the ammeter to vibrate during the cranking operation. If the lights are on, the meter will show a heavier discharge.

The main cranking current is not conducted through the ammeter, as this is a very heavy current and it would be impossible to conduct this heavy current through the ammeter and still have an ammeter that is sensitive enough to indicate accurately the charging current and the current for lights and ignition.

As soon as the engine fires the starting pedal should be released immediately, as the overrunning motor clutch is operating from the time the engine fires until the starting gears are out of mesh. They operate at a very high speed and if they are held in mesh for any length of time, there is enough friction in this clutch to cause it to heat and burn out the lubricant. There is no necessity for holding the gears in mesh.

Motor Clutch.

The "motor" clutch operates between the fly wheel and the armature pinion and is for the purpose of getting a suitable gear reduction between the motor generator and the fly wheel. It also prevents the armature from being driven at an excessively high speed during the short time the gears are meshed after the engine is running on its own power.

This clutch is lubricated by the grease cup D, shown in (fig. 1, chart 188-B.) This forces grease through the hollow shaft to the inside of the clutch. This cup should be given a turn or two every week.

How One Armature is Used for Starting Motor also Generator.

When the cranking operation is finished the motor brush switch is raised off the commutator by the pin (P) when the starting pedal is released. This throws the starting motor out of action. As the motor brush is raised off the commutator the generator switch makes contact and completes the charging circuit. The armature is then driven by the extension of the pump shaft and the charging begins.

Charging current: At speeds above, approximately 7 miles per hour, the generator voltage is higher than the voltage of the storage battery, this causes current to flow from the generator in the charge direction to the storage battery. As the speed increases, up to approximately 20 miles per hour, this charging current increases also, but at the higher speeds the charging current decreases.

The curve on page 390 shows approximately, the charging current that should be received for different speeds of the car. There will be slight variations from this, due to temperature changes and conditions of the battery which will amount to as much as from 2 to 3 amperes. The regulation of the generator current is explained on page 389. Which in this particular instance is the "third brush regulation."

Generating Electrical Energy.

If we have a generator in which the magnetic field remains constant and the generator produces 7 volts at 400 R. P. M., the voltage at 800 R. P. M. would be 14 volts, and it is on account of this variable speed of generator for automobile purposes that they must be equipped with some means of regulation for holding the voltage very nearly constant. The regulation of this generator is by what is known as **third brush excitation, the theory of which is as follows:**

*The motor-generator consists essentially, of an iron frame and two field windings for magnetizing the pole pieces. The armature, which is the revolving element, has wound in slots on its iron core, a motor winding and a generator winding, connected to corresponding commutators. Each commutator has a corresponding set of brushes which are for the purpose of collecting current from, or delivering current to the armature windings while it is revolving.

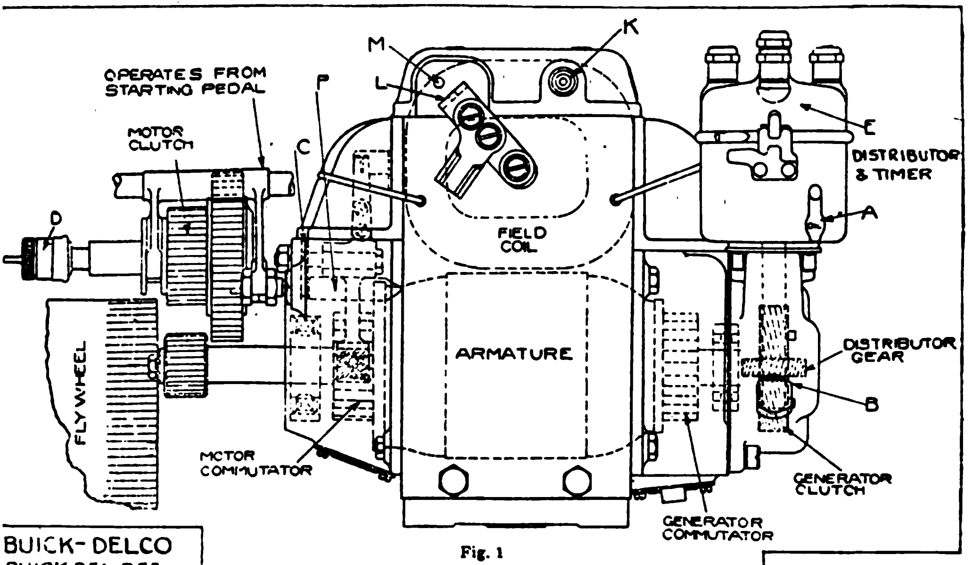
When cranking, current from the storage battery flows through the motor winding, magnetizing the armature core and coils, and also the fields. This being acted upon by the magnetism of the pole pieces or the "field of force" between them causes the turning effort.

When generating, the voltage is induced in the generator winding and when the circuit is completed to the storage battery this causes the charging current to flow into the battery.

How "direct" current is obtained: The current flows in one direction in a given coil while under the influence of one pole piece, and in the other direction when under the influence of the opposite pole. If these cur-

---

*The motor generator serves both as a generator and as an electric motor for cranking the engine when starting. There are two windings on the armature and two in the field—one on the armature and one on the field are used when the motor generator is used as a generator and the other windings when it is used as a motor. See Cadillac-Delco wiring diagram, page 396.



BUICK-DELCO
BUICK D54-D55

Fig. 1

NOTE.—On the later models a change has been made in the oiler at B.

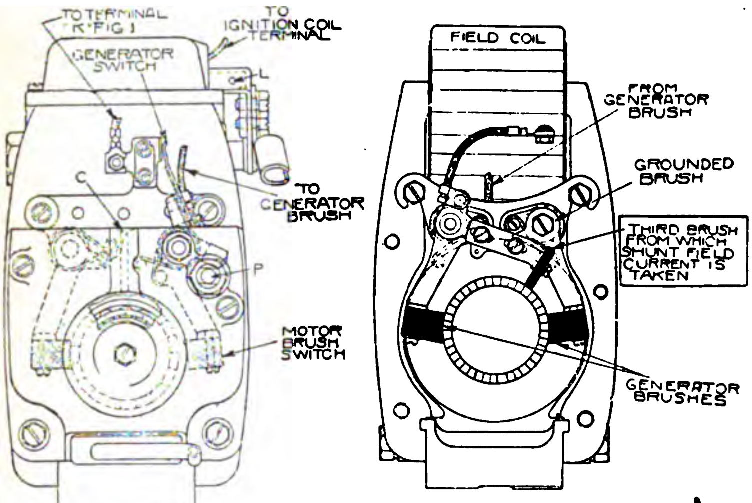
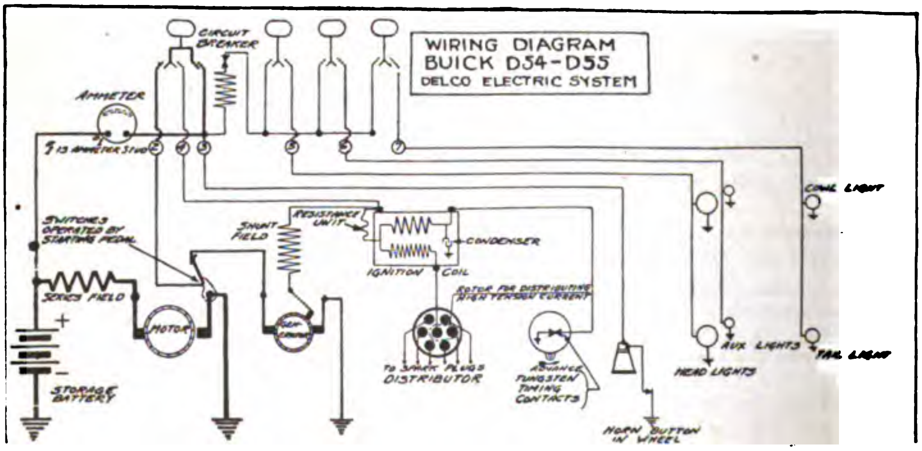


Fig. 2

The output of these generators can be increased or decreased by changing the position of the "third brush." Each time the position of the brush is changed it is necessary to sandpaper it so that it fits the commutator per page 404. Otherwise the charging rate will be very low, due to the poor contact.

The charging current should be carefully checked, and in no case should the maximum current on this generator exceed 22 amperes. Careful watch should be kept on machine on which the charging rate has been increased, to see that commutator is not being overloaded.

Note generator clutch connects with pump shaft not shown (see page 377 how distributor shaft is driven).



ART NO. 188B—The Delco "Single Unit" System with "Third Brush Regulation" of the Shunt Field Winding—system used on the Buick D54-D55. **The cut-out is not used.**

On the "Buick-six" 1918 model—the generator and motor commutators are at front end of armature. The ignition coil (fig. 4, page 245), is placed on top of motor generator. Wiring etc. otherwise is similar.
***See page 497 for dash board and control of the Buick.**

rents were collected through "slip rings" instead of a commutator, they would be true alternating currents. But as we want "direct" current, we commute them (or turn them in one direction) through the medium of a commutator. Each segment on the commutator represents one end of a coil or set of coils, dependent on the way it is wound. There are many ways of winding and connecting armature coils, but the principle is as outlined above.

When the ignition button on the combination switch is first pulled out the current flows from the storage battery through the generator armature winding, also through the shunt field winding. This causes the "motoring of the generator."

After the engine is started and is running on its own power this current still has a tendency to flow in this direction, but is opposed by the voltage generated. At very low speeds a slight discharge is obtained. At approximately 7 miles per hour the generated voltage exceeds that of the battery and charging commences. As the speed increases above this point the charging rate increases as shown by the curve (fig. 15, page 390).

The ignition current flows only when the contacts are closed, it being an intermittent current. The maximum ignition current is obtained when the circuit is first closed and the resistance unit on the rear end of the coil is cold. The current at this time is approximately 6 amperes, but soon decreases to approximately 3½ amperes. Then as the engine is running, it further decreases until at 1000 revolutions of the engine it is approximately 1 ampere.

**Third Brush Regulation.

The regulation of this generator is effected by what is known as third brush excitation. From the foregoing explanation of the generating of electricity and from the fact that the voltage generated varies directly with the speed, **it is evident in order to maintain a nearly constant voltage with a variable speed, it becomes necessary to decrease the magnetic field as the speed increases.**

Since the magnetic field of the generator is produced by the current in the shunt field winding it is evident that should the shunt field current decrease, as the speed of the engine increases the regulation would be affected. In order to fully understand this explanation it must be borne in mind that a current of electricity always has a magnetic effect whether this is desirable or not.

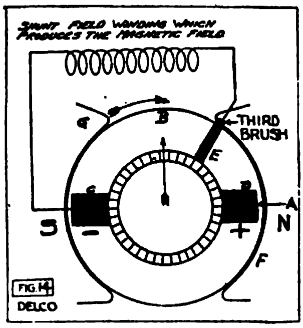


Fig. 14. The Delco third brush regulation: The third brush (E) is adjustable. On the "single unit" Delco systems this brush is exposed when the front end cover of generator is removed. On all "two unit" systems the third brush is located on the lower side of commutator.

Moving this brush in direction of rotation, increases the charging rate to battery.

Moving brush in opposite direction decreases the charging rate.

Referring to (fig. 14) the theory of this regulation is as follows: The full voltage of the generator is obtained from the large brushes marked "C" and "D." When the magnetic field from the pole pieces N and S is not disturbed by any other influence each coil is generating uniformly as it passes under the pole pieces.

***The voltage from one commutator bar to the next one gradually increases,** from zero to full voltage (dependent on position of coil to which commutator bar is attached).

The voltage from brush C to brush E is about 5 volts when the total voltage from brush C to brush D is 6½ volts and 5 volts is applied to the shunt field winding. This 5 volts is sufficient to cause approximately 1¼ amperes to flow in shunt field windings.

As the speed of the generator is increased, the voltage increases, causing the current to be charged to the storage battery.

The charging current flows through the armature winding, producing a magnetic effect in the direction of the arrow B. This magnetic effect acts upon the main magnetic field which is in the direction of the arrow A with the result that the magnetic field is twisted out of its original position in very much the same manner as two streams of water coming together are each deflected from their original directions. This deflection causes the magnetic field to be **strong** at the pole tips marked G and F, and **weak** at the opposite pole tips, with the result that the coils generate a very low voltage while passing from the brush E to the brush D (the coils at this time are under the pole tips having a weak field) and generates a greater part of their voltage while passing from the brush C to E. The amount of this variation depends upon the speed that the generator is driven; with the result that the shunt field current decreases as the speed increases as shown in the curve (fig. 15.)

***Roughly speaking, zero potential** is midway between the pole pieces and at maximum when leaving pole horns, as at points G and F. ****See also page** 925 for **explanation** of the **Bijur third brush system** and pages 343 and 345 for different generator regulation systems.

By this form of regulation it is possible to get a high charging rate between the speeds of 12 and 25 miles per hour, and it is with drivers whose average driving speed comes between these limits that more trouble is experienced in keeping the battery charged. **At the higher speeds the charging current is decreased.** The driver who drives his car at the higher speeds requires less current, as experience has taught that this type of driver makes fewer stops in proportion to the amount the car is driven than the slower driver.

Regulating Charging Current.

The output of these generators can be increased or decreased by changing the position of the regulating brush. Each time the position of the brush is changed it is necessary to sand paper the brush so that it fits the commutator. Otherwise the charging rate will be very low due to the poor contact of the brush. This should not be attempted by any one until thoroughly understood, and this charging current should be carefully checked and in no case should the maximum current on this generator exceed 22 amperes. Also careful watch should be kept on any machine on which the charging rate has been increased to see that the commutator is not being overloaded.

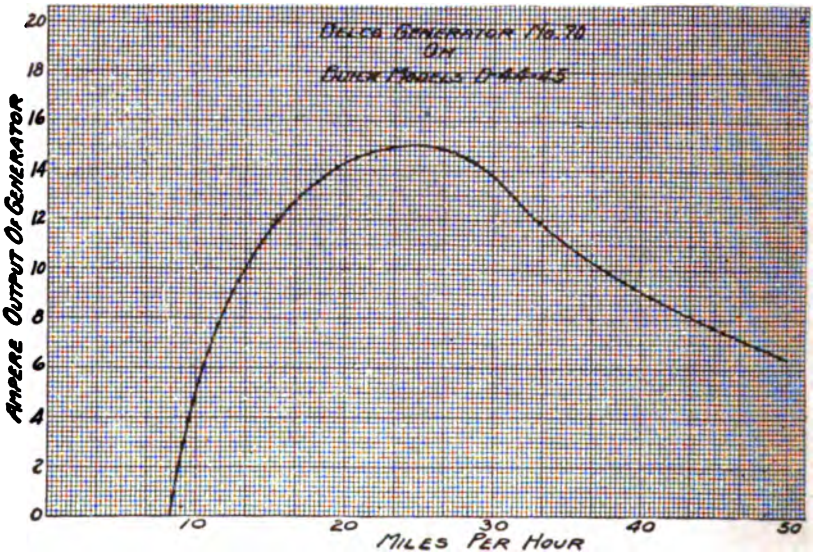


Fig. 15—Showing the amperage of the Delco generator at various speeds. Note the shunt field current decreases as the speed increases above 25 miles per hour.

To read this chart, note the miles per hour are shown at the bottom, and the ampere output at the left side of chart. Example: At a car speed of 20 miles per hour what is the ampere output? Find 20 at the bottom and follow vertical line until it meets the black wave line, then follow horizontal line to the left edge and we find 14 amperes,—the output at this speed. At higher speeds, say 35 miles per hour, the output drops to 11 amperes, and at 40 miles it drops to 9 amperes.

Considerable variation (from the curve shown) in the output of different generators, will be obtained as the generator is affected by temperature and battery conditions.

*To Time the Delco Ignition.

When timing the spark the cam A (fig. 7, page 378) is moved with respect to the shaft upon which it is mounted, which is done by loosening a screw (A) in the end of the shaft and again tightening it after the cam has been moved the desired amount. Turning the cam in a **clockwise** direction, or toward the right, **advances** the time of ignition, and **counter-clockwise**, or to the left, **retards** it. **To adjust timer,** see page 378.

To time Hudson-Delco; place spark lever at top of steering wheel quadrant. Place No. 1 cylinder piston on top of compression stroke. No. 1 cylinder is due to fire in **advanced** position, when mark (A) on fly wheel reaches the pointer attached to the crank case. This may be observed through the inspection hole on the fly wheel housing left side of engine. Mark (A) is **⅛" before top center** (top center is marked D-C-1 & 6).

Loosen cam and set to break at this point. The adjusting screw A, fig. 8, page 377 and fig. 7, page 378, on the cam must always be set tight after changing adjustment. The spark occurs at the instant timer contacts are open.

In checking the timing, the cam should be held on tension in the opposite direction of rotation so that all back lash is taken up when rotor button comes under No. 1 contact on distributor head.

After checking the timing replace rotor (K), fig. 8, page 377. Rub a little vaseline on the rotor track of the distributor head before seeing that it is down tight in position.

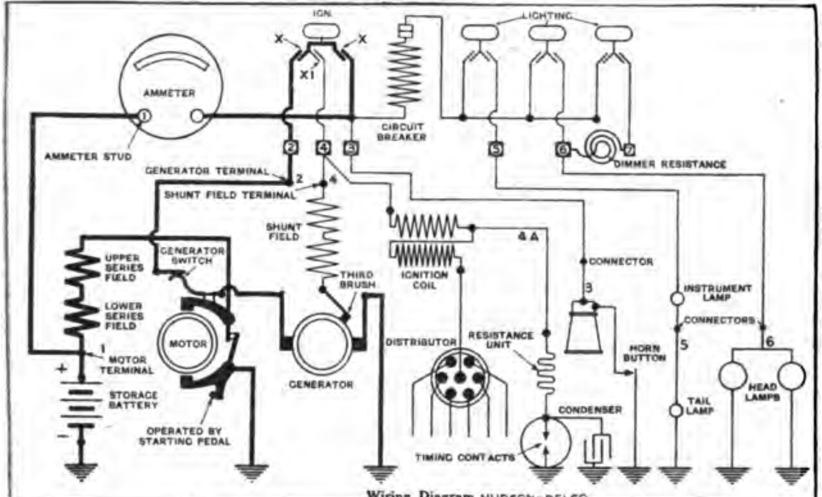
†To time Buick "six" and "four;" see page 246.

To time Cadillac-Delco; see pages 132 and 739.

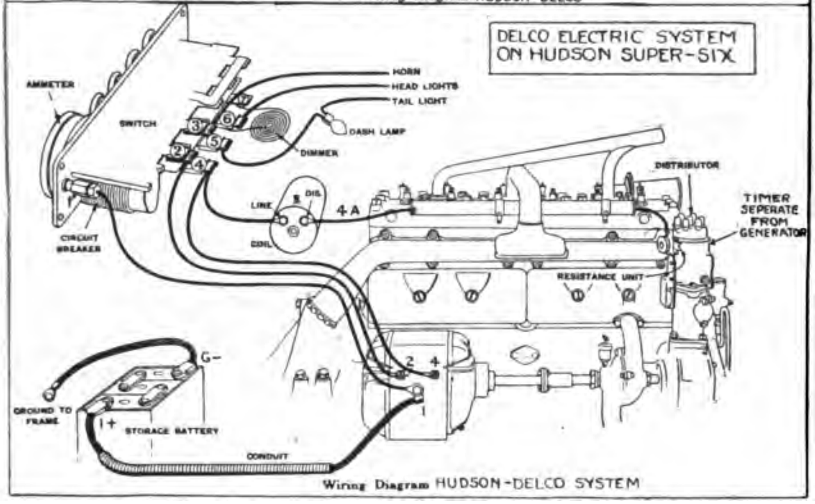
*See page 542—"Standard Adjustments." †Also for Buick "D44 to 47."

**See pages 543 to 546 for cars using Delco system.

Fig. 1.



Wiring Diagram HUDSON-DELCO



Wiring Diagram HUDSON-DELCO SYSTEM

Hudson-Delco Generator.

A new feature of this generator which differs from the Hudson system in charts 187, 188, and 188A is the third brush method of regulation as shown in chart 188B. Referring to this chart, it will be seen that all the current passing through the shunt field winding must pass through this third brush. At the higher speeds of the armature the voltage at this third brush decreases, and less current will flow through the shunt windings thus weakening the magnetic field of the generator. This decreases the output of current at high speeds.

The output can be varied by adjusting the third brush; moving this brush to the left decreases the charging rate; moving it to the right increases the charging rate.

The adjustment of this brush should not be changed except when absolutely necessary, and must be carefully checked to make sure that the charging rate is not above the capacity of the generator or battery.

The brush must be sanded to fit the commutator each time it is adjusted. (See chart 188-K. and L.) Poor contact lowers the charging rate. **If the charging rate is materially increased,** the battery will be subjected to an overcharge and the voltage of the entire system will be raised. This will shorten the life of the lamps and battery and cause excessive burning of breaker contacts.

Motor Circuit.

When the starting gears are meshed as explained on page 385, further depression of the starting pedal causes the generator switch to break contact, thus opening the generator circuit. When the starting pedal is fully depressed the motor brushes make contact with the motor commutator, thus closing the motor circuit, and the cranking operation commences. The current now flows through the heavy cable and around the windings of the armature and motor field. During the cranking operation, current will flow through the combination switch at contacts X-1, fig. 1, and through the shunt field winding. Thus the motor operates as a compound wound starting motor.

Ignition Circuit.

When the ignition button is pulled out, contacts X fig. 1 are closed. This allows current from the storage battery to flow through these contacts, then through terminal 4 to the ignition coil; then through the primary winding of the ignition coil and the timing contacts to ground. The high tension part of the ignition system produces the spark at each spark plug when the engine is being cranked, causing the engine to start and run on its own power. Note when the engine is running and generator delivering current to the storage battery, the ignition current is taken direct from the generator, instead of from the storage battery. Otherwise the circuit is the same.

Distributor and Timer.

The distributor and timer is separate from the motor-generator, and is carried on the front of the engine above the timing gears. It is driven by spiral gears from the pump shaft.

To time the ignition, see page 390. The timer is of the **closed** circuit type, fig. 7, page 378.

CHART NO. 188C—Hudson "Super-Six"—Delco Electric System: A "Two-unit" System. "Single," or grounded return wire. Ignition is "automatic advance," using **a closed circuit type** interrupter. See pages 382, 384 and 385 for Hudson "Six-40" Delco system.

See page 437 for explanation of the resistance type "dimmer" as shown above connected to 6 and 7.

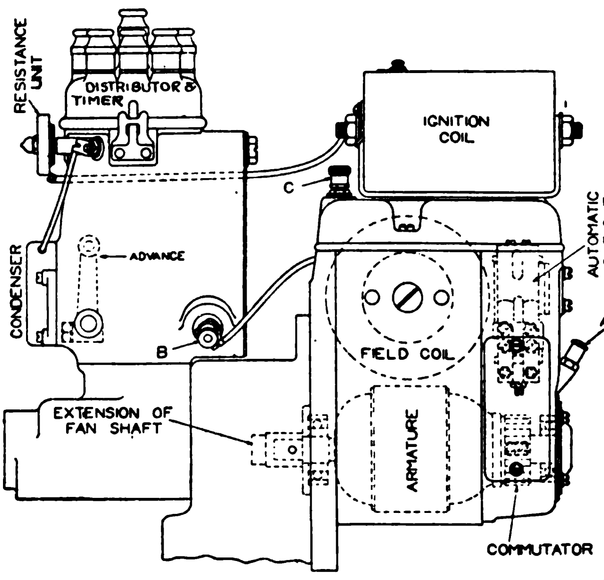
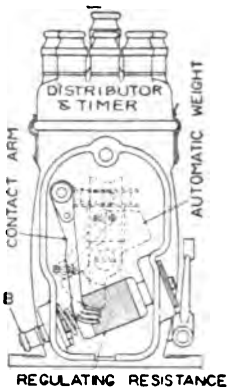


Fig. 3 Generator.



This Delco system differs from previous systems explained, in that the starting motor is separate and employs the Bendix drive system as explained in chart 160.

The generator therefore does not combine the principle of a motor and generator. Only one commutator is used.

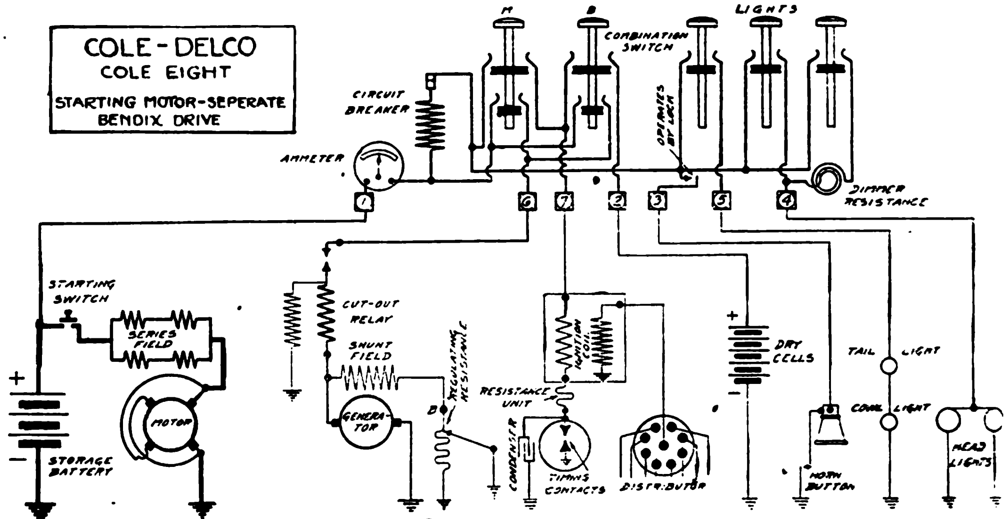
The field coil contains the shunt winding which is for the purpose of producing the magnetic field, the connections of which are shown in the circuit diagram, and the location of the coil is also shown.

"Variable resistance regulation" is employed to control the output of generator as explained in chart 188, fig. 3.

The charging current increases as the speed of the generator increases, until the regulating arm in the distributor moves on to the wire on the regulating resistance (see above), which inserts resistance in the shunt field circuit and decreases the strength of the magnetic field in the generator, thereby controlling the output or charging current. This is called the "variable resistance" regulation as previously explained.

A "cut-out" is employed in this system to open and close the circuit between the battery and generator. This "cut-out" is not used on many of the other Delco systems.

The timer fig. 37, is of the open circuit type—see fig. 6, page 378.



COLE Wiring Diagram.

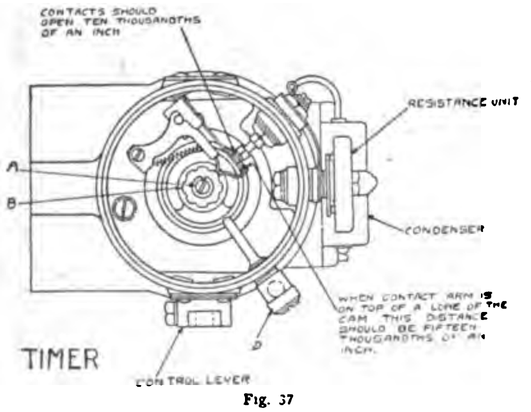

CONTACTS SHOULD OPEN TEN THOUSANDTHS OF AN INCH
RESISTANCE UNIT
A
B
CONDENSER
WHEN CONTACT ARM IS ON TOP OF A LOBE OF THE CAM THIS DISTANCE SHOULD BE FIFTEEN THOUSANDTHS OF AN INCH.
D
CONTROL LEVER
TIMER

Fig. 37

CHART NO. 188D—Cole Eight—Delco Electric System. The starting Motor is separate with a Bendix Drive System. The Regulation of current output is the "Variable Resistance method as explained in chart 188. This is a grounded wire "two unit system." A magnetic "cut-out" is employed.

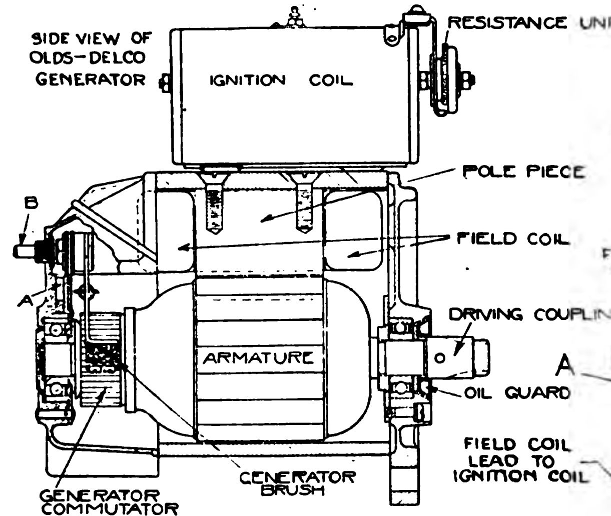
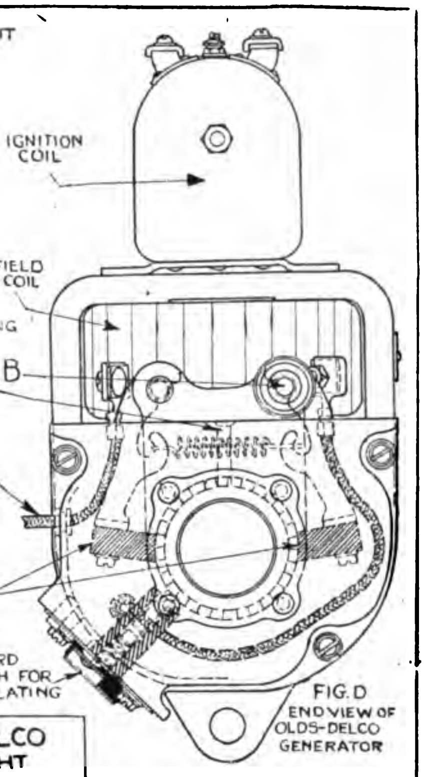


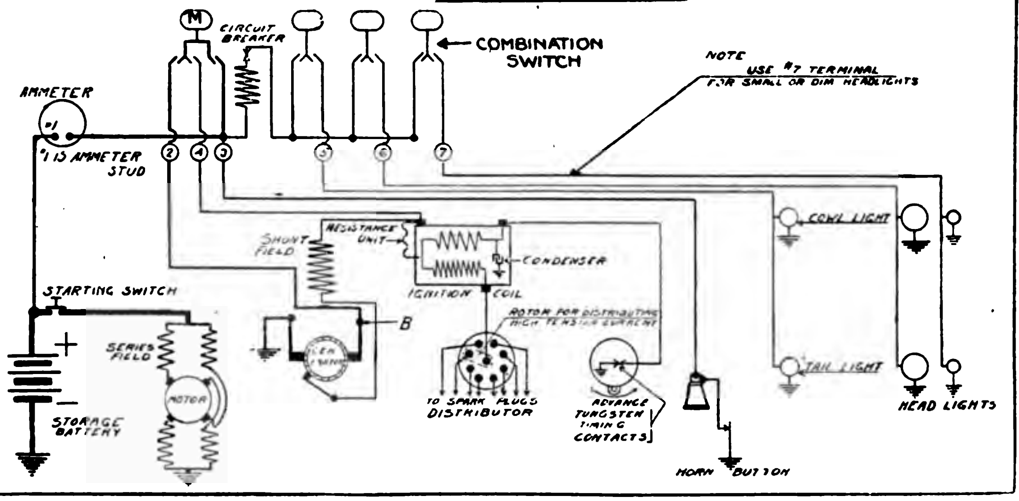
Fig. C.

OLDSMOBILE EIGHT ELECTRIC SYSTEM

It is a three-unit, six-volt, grounded system
Starting Motor. BENDIX DRIVE
Starting Motor Switch.
Generator. DELCO
Combination Switch
Distributor.&TIMER-DELCO- SEPERATE
Ignition Coil.


IGNITION COIL
FIELD COIL
A
B
FIELD COIL LEAD TO IGNITION COIL
GENERATOR BRUSHES
THIRD BRUSH FOR REGULATING
FIG. D
END VIEW OF OLDS-DELCO GENERATOR

OLDS-DELCO
OLDS EIGHT



The Delco generator employs the "third brush" system of regulation as shown in fig. D, above and as previously explained.

The wiring principle is the grounded return wire system. Note the wires are run in flexible conduit—see chart 188F.

The ignition is similar to the other Delco systems previously explained with automatic advance. The distributor and timer are located in front of the engine and driven by gears from the same shaft which drives the generator.

The starting motor on the Olds is separate from the Delco generator.

The starting motor is located back of the flywheel on the lower right side. This is a four-pole series wound motor, the circuit of which is very plainly shown in the circuit diagram (above). It will be noted that each field coil is connected in parallel with another field coil and each of these are in series with the armature winding. It is connected in such a manner that the armature is in the circuit between the two pairs of field windings.

The starting switch is located on the toe board and connected in the circuit between the storage battery and the starting motor. The drive between the starting motor and flywheel is by means of the Eclipse-Bendix gear which is entirely automatic in its performance. (See chart 188F).

CHART NO. 188E—Olds Eight—Delco Electric System: Starting Motor separate with Bendix Drive. Generator with "Third Brush" Regulation. Ignition separate. A "Three-unit" system. Automatic advance of spark.

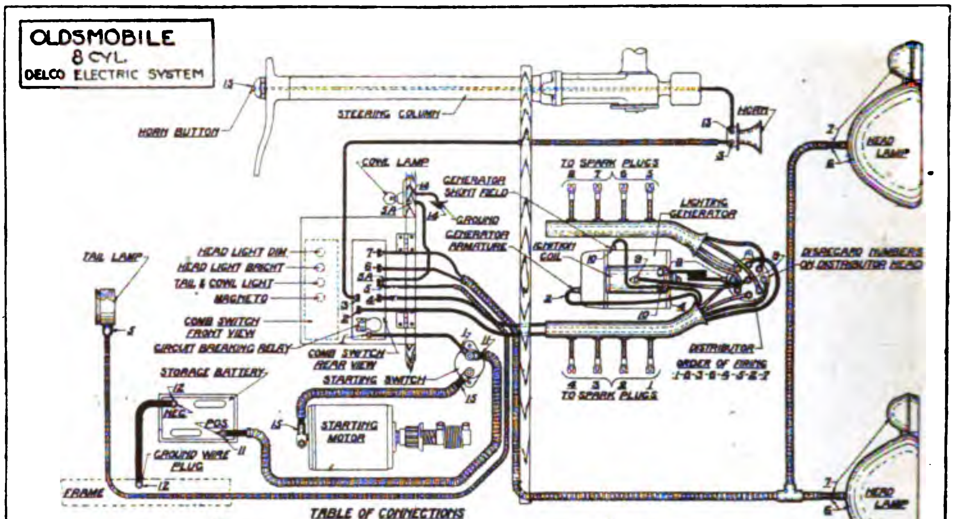


TABLE OF CONNECTIONS

FROM	TO	FROM	TO
1 WIRE ON COMB. SWITCH	1 ON STARTING SWITCH	8 WIRE ON IGNITION COIL	8 ON DISTRIBUTOR
2 " " " "	2 " GENERATOR ARMATURE	9 " " " "	9 " "
3 " " " "	3 " HORN	10 " " GEN. SHUNT FIELD	10 " IGNITION COIL
4 " " " "	4 " IGNITION COIL	11 " " STARTING SWITCH	11 " POSITIVE BATTERY
5 " " " "	5 " TAIL LIGHT	12 " " NEGATIVE BATTERY	12 " GROUND
5A " " " "	5A " COWL "	13 " " HORN	13 " HORN BUTTON
6 " " " "	6 HEAD " (BRIGHT)	14 " " COWL LIGHT	14 " GROUND
7 " " " "	7 " " " (DIM)	15 " " STARTING SWITCH	15 " STARTING MOTOR

Oldsmobile-Delco, electric diagram as referred to on page 393.

A Delco electric system — ignition with non-automatic spark.

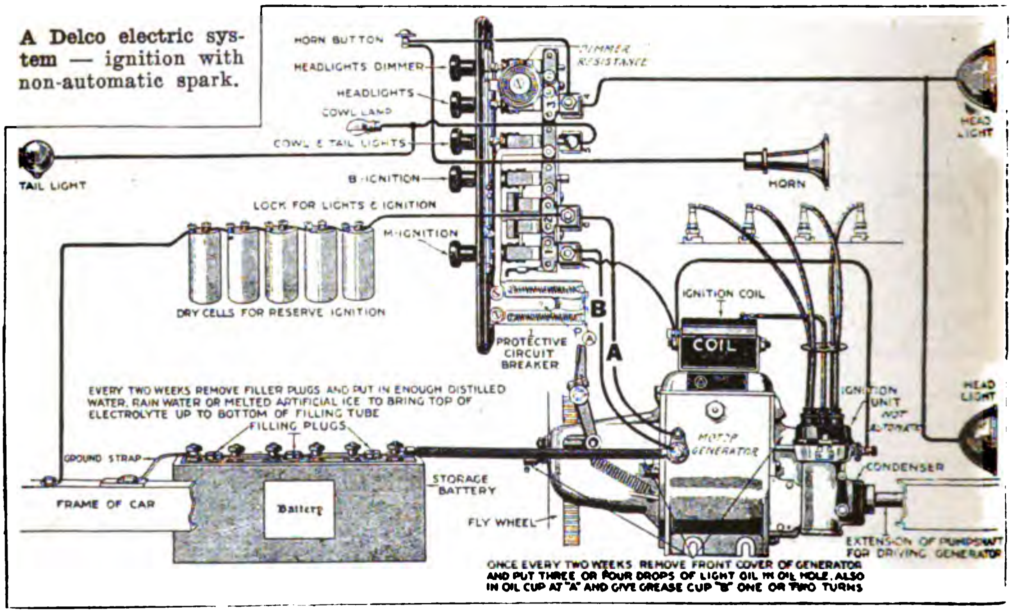

HORN BUTTON
HEADLIGHTS DIMMER
HEADLIGHTS
COWL LAMP
COWL & TAIL LIGHTS
B-IGNITION
LOCK FOR LIGHTS & IGNITION
M-IGNITION
DIMMER RESISTANCE
TAIL LIGHT
HORN
HEAD LIGHT
DRY CELLS FOR RESERVE IGNITION
IGNITION COIL
COIL
B
A
PROTECTIVE CIRCUIT BREAKER
EVERY TWO WEEKS REMOVE FILLER PLUGS AND PUT IN ENOUGH DISTILLED WATER, RAIN WATER OR MELTED ARTIFICIAL ICE TO BRING TOP OF ELECTROLYTE UP TO BOTTOM OF FILLING TUBE
FILLING PLUGS
GROUND STRAP
FRAME OF CAR
Battery
STORAGE BATTERY
FLY WHEEL
MOTOR GENERATOR
IGNITION UNIT NOT ALTERNATOR
HEAD LIGHT
CONDENSER
EXTENSION OF PUMPSHAFT FOR DRIVING GENERATOR
ONCE EVERY TWO WEEKS REMOVE FRONT COVER OF GENERATOR AND PUT THREE OR FOUR DROPS OF LIGHT OIL IN OIL HOLE. ALSO IN OIL CUP AT "A" AND GIVE GREASE CUP "B" ONE OR TWO TURNS

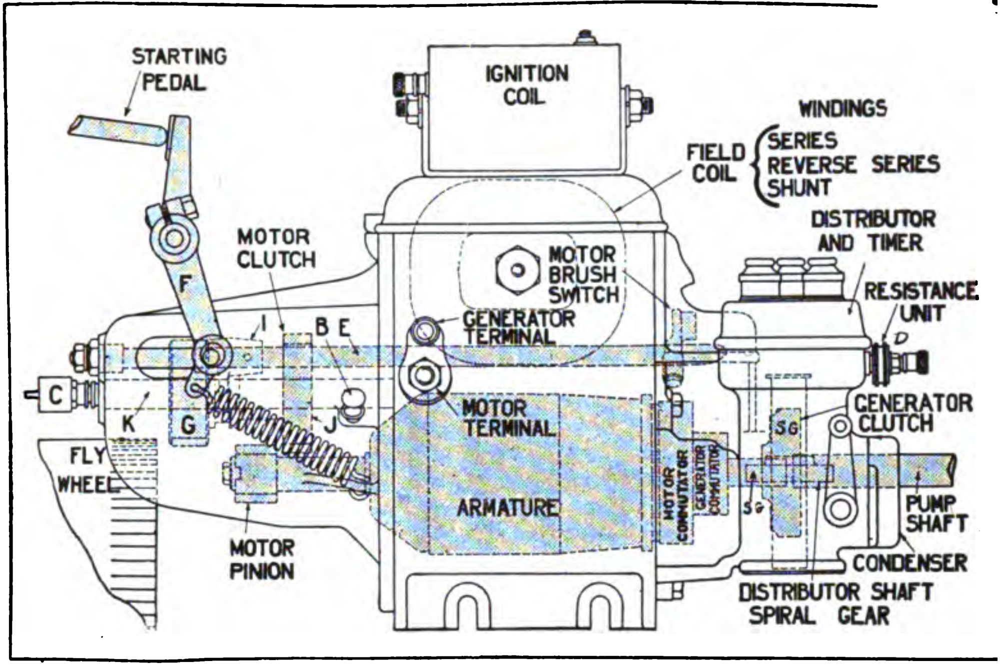
Fig. 2. Illustration shows a Delco system with non-automatic spark advance and an armature with both commutators on one end. This illustration shows a diagramatic view while fig. 1, chart 188G shows the circuit view.

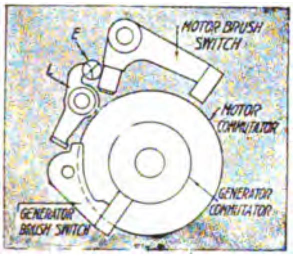
The regulation is called the "reverse-series"—see diagram in chart 188G. The principle otherwise is identically the same as other Delco systems.

Ignition—Note the coil is mounted on the top of the motor-generator, it could be mounted on the dash under the hood.

The timer (see chart 188G) is a four point therefore for a four cylinder engine, note ignition resistance unit and condenser is mounted on timer in this instance, instead of the coil, as per fig. 4, page 245.

CHART NO. 188F—Oldsmobile Eight—Delco Electric System. Also see chart 188E. Another Delco System is shown in fig. 2, which is a diagramatic view of system illustrated in chart 188G.





STARTING OPERATION

Illustration shows the operation of the generator and the mot brush switches, both of which are operated by the Pull Rod "E. This also operates the starting gear. The complete starting oper tion is as follows:

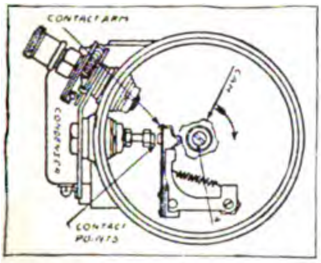
1. When either the "M" or "B" button on the Combinati Switch is pulled out the circuit between the generator and the stora battery is closed. The current will flow from the storage batte through the generator windings, which causes it to rotate slowly.

2. As the starting pedal is pushed out, it operates the pull r "E" which causes the gear "J" of the motor clutch to mesh wi the motor pinion, and this causes the motor clutch to rotate slowl As the pedal is pushed further out the gear "G" meshes with t teeth on the face of the flywheel.

3. As soon as the gears are meshed on the flywheel, the pull r "E" raises the lower generator brush off the commutator. (Al see below).

4. When the pull rod "E" has been moved far enough by t starting pedal to bring the gears fully in mesh, it then allows t motor brush to drop on the commutator and completes the cranki circuit.

After the Engine is started, the pull rod (E), throws gear ((out of mesh with fly wheel, raises the motor brush (MB), plac the generator brush (GB), on its commutator. (See below).



The timer for a four-cylinder engine has but four lobes, or projections.

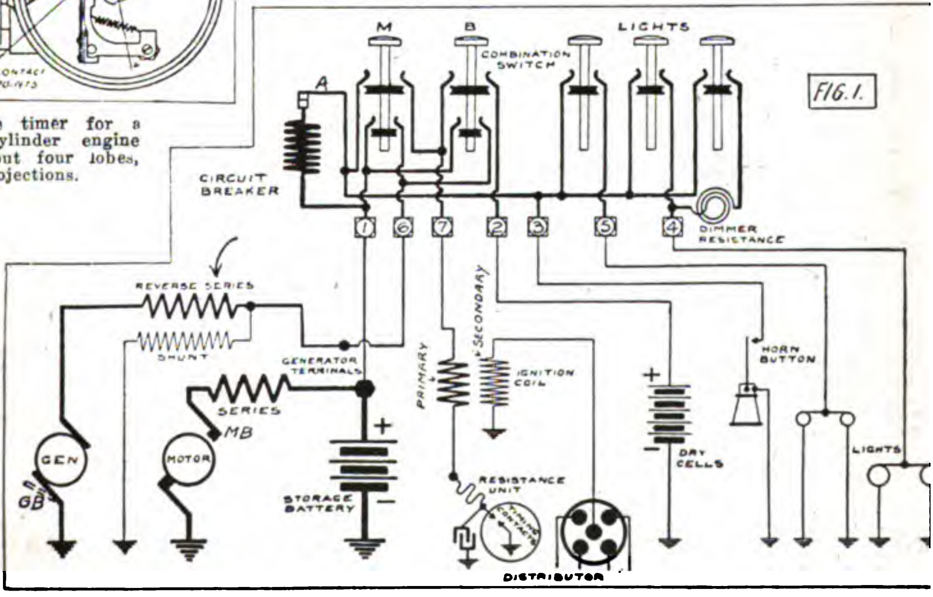


CHART NO. 188G—The Delco System where the Motor and Generator Commutators are pl on same end of Armature. Timer above open-circuit type. (Late systems, (B) switch elimina

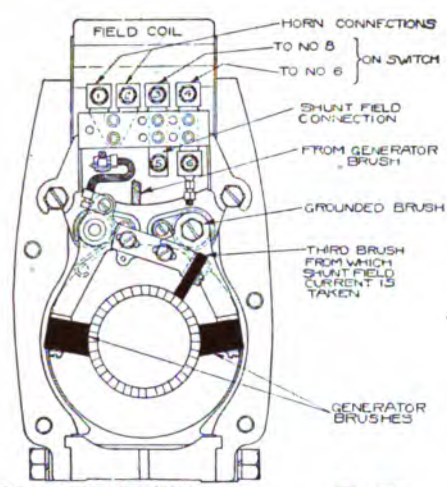


FIG 8 GENERATOR END VIEW CADILLAC-DELCO Fig. 8.

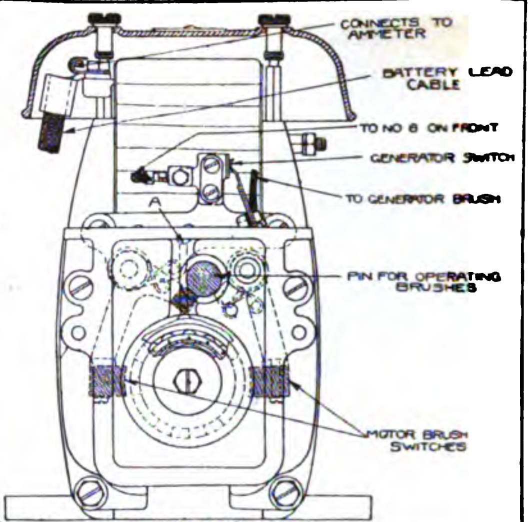
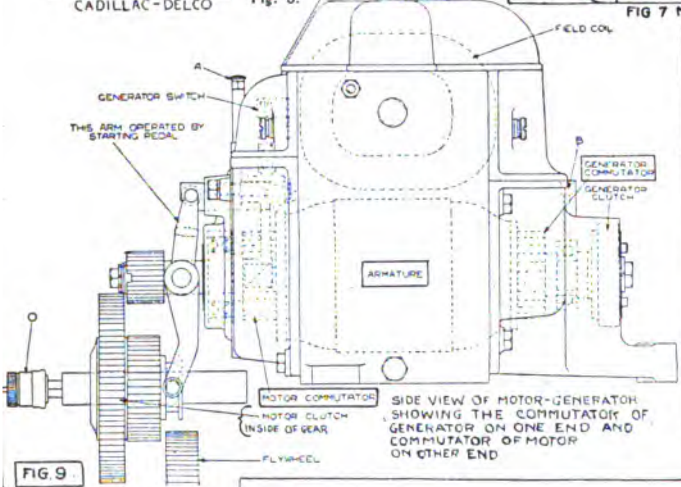


FIG 7 MOTOR END VIEW



SIDE VIEW OF MOTOR-GENERATOR SHOWING THE COMMUTATOR OF GENERATOR ON ONE END AND COMMUTATOR OF MOTOR ON OTHER END

FIG. 9

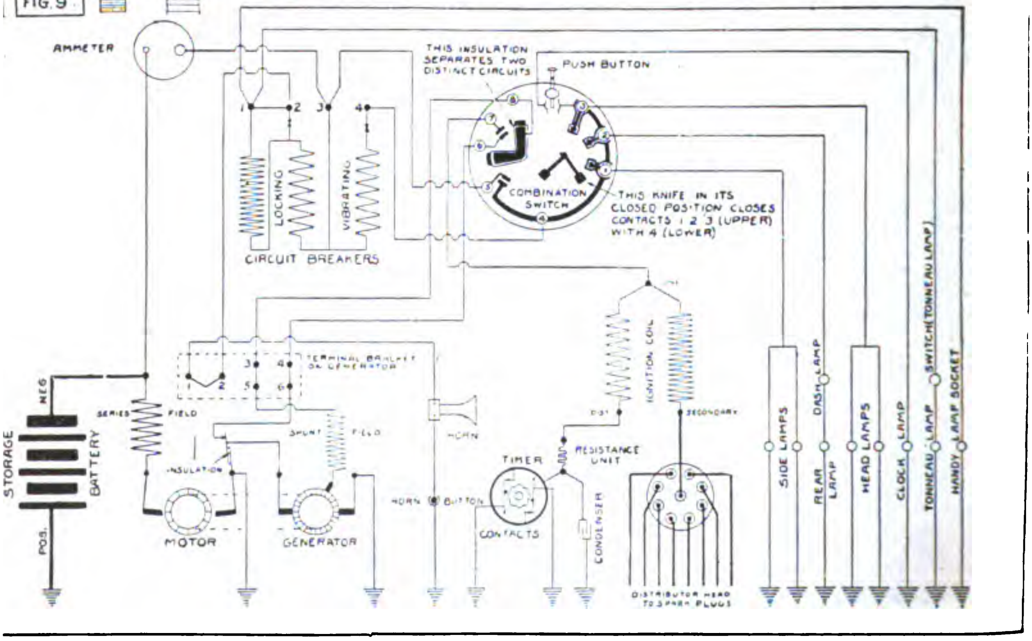
The Cadillac Eight—Delco system differs but little from other Delco systems. The starting and generating of current is by means of one armature with commutator at each end. The "third brush" regulation system is employed.

The general principle of meshing gears is as per pages 376 and 388.

See pages 132 and 133 for Delco-Cadillac ignition wiring diagram.

The type 51 Cadillac used a "variable resistance" in the shunt winding of generator, whereas the type 53, 54, 55, 57 uses the "third brush" regulation as shown above.

See foot note bottom page 387 relative to windings on armature and field.



HART NO. 188H—Cadillac—Delco Electric System. Also see pages 132 and 133. This system is a "Two-unit" single or grounded return, system of wiring.

INSTRUCTION No. 28-C.

CARE, TESTS AND ADJUSTMENTS OF DELCO ELECTRIC SYSTEMS: Lubrication. Size of Resistance Units to Use. Removing Generator Clutch. Testing for Defective Condenser and Ignition Coil. Testing Light Circuits, Short Circuits, Open Circuits, Armature, Field Windings, Etc. Volt-Ammeter for Testing. Principle and Construction of a Volt-Ammeter. Test Light. Hints for Locating Delco Troubles. Adjusting Third Brush Regulation. Commutator and Brush Adjustments, Etc. Repairing Commutator, Etc.

Lubrication of the Delco System.

There are five principal places to lubricate the Delco System. 1—The grease cup for lubricating the motor clutch (D) fig. 1, page 388. 2—Oiler for lubricating the generator clutch and forward armature bearing (B) 3—The oil hole (C) for lubricating the bearings on the rear of the armature shaft. This is exposed when the rear end cover is removed and should receive oil once a week. 4—The oil hole in the dsitributor for lubricating the top bearing of the distributor shaft is at (A) and should receive oil once a week. 5—The inside of the distributor head. Lubricate with a small amount of vaseline, carefully applied two or three times during the first 2000 miles running of the car, after which it will require no further attention. It is desirable to secure a burnished track for the rotor brush on the distributor head. The grease should be sparingly applied and the head wiped clean from dust and dirt. (see page 377.)

Sizes of Delco Regulating Resistance Units to Use.

***Regulating resistance** spools shown at B, fig. 3, page 384, are individually suited to the generators in which they are installed and are marked. Those spools marked No. 817 have the greatest resistance and consequently give the smallest charge. Those marked No. 701 to 703 have less resistance and give a greater charging rate—No. 703 giving the greatest, and the others in proportion.

Since the contact arm (C) (operated by the centrifugal governor) is on the lower coil when running slowly, the resistance spools will not affect the output at these speeds. It is at speed of over 20 miles an hour when the arm has begun to travel over the coil, that the amount of resistance in the circuit affects the output.

In testing the output an ammeter should be inserted between terminal 6 and wire 6 on the generator. (See fig. 2, page 382). On no account should the output exceed 20 amperes, regardless of the speed of the car.

Between 15 and 20 miles an hour, the output should be 12 to 15 amperes, and will gradually decrease as the car speed increases.

Before testing the output of the generator the condition of the battery should be noted. A battery showing about 1250 gravity test is best adapted for checking the generator. (see pages 450 and 451.)

In removing and replacing the resistance units great care should be exercised not to bend the contact arm so that it bears too hard on the spool, or so that it does not touch sufficiently hard to make a good contact. The former makes the arm stick when in the higher position, reducing the charging rate, and the latter increases the resistance, and causes arcing on the resistance unit, eventually burning it out. The resistance units must be snapped into place between the spring retainers so that there is a good contact. When there is no contact the generator is not delivering any current.

By installing a spool of larger size wire the maximum charging rate is but slightly increased and a higher rate is secured above the maximum point. By installing the spool with the wide cap at the bottom the maximum charging rate is increased, with a corresponding increase at higher speed.

*On the generators, which are driven at or near engine speed, the spool 702 is most often used, but 701 and 703 are sometimes used. On generators Nos. 52 and 58, which are driven at 1½ times engine speed, spools Nos. 817 and 955 are used. This "variable resistance" regulation is now seldom used. The "third-brush" regulation being the modern method.

*Cutout Adjustment.

In order to adjust the cut out so that it acts at the proper time, two things must be kept in mind—the tension on the spring and the air gap between the armature and core. The air gap has little or no effect upon the point of cutout, as this is governed by the spring tension. On the other hand, the cutting in is governed by both the air gap and the spring tension.

Suppose, for example, that the cutout closes at 8 volts and opens on a discharge current of 2 amperes. To reduce the cut-in voltage, and in order to break the circuit on a 1-ampere discharge, the spring tension must be reduced.

The cutout is supposed to operate between $6\frac{1}{2}$ and $7\frac{3}{4}$ volts and the air gap should be adjusted accordingly. It is supposed to open when the discharge current is between zero and 1 ampere, and preferably as near zero as possible to reduce arcing.

When properly adjusted the air gap should be approximately 1/32 in. when the contacts are closed by a slight depression with the finger.

How to Remove the Delco Generator Clutch.

Figure 16 gives two views of the generator clutch. **This clutch is removed from the armature and end frame assembly by** loosening the screw in the end of the armature **shaft** and removing the lock washer and key washer. Cut a hole in the work bench about ¼ inch larger in diameter than armature. Insert armature through this hole. Allow the armature and end frame to drop about two inches, being careful to have the end frame come squarely in contact with the bench.

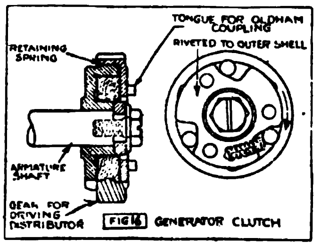


FIG 16 GENERATOR CLUTCH

Hold the armature from below so that it will not be injured by striking the floor.

The clutch is held together by a retaining spring wire which when removed allows the clutch to be disassembled for inspection. (see page 386 explaining clutch action.)

Miscellaneous Delco Tests.

A defective condenser: The action of the timer contacts can be observed by removing the distributor head and cranking the engine with the starter. A defective condenser will cause serious sparking at the timer points. A slight spark at the timer points will sometimes be observed with a good condenser.

The mechanic should familarize himself **with the spark obtained, by removing the** wire from one of the plugs and letting the spark jump to the engine. (Not to the spark plug.) A good coil will produce a spark with a maximum jump of at least ½ inch, provided other conditions are normal.

†Ignition Coil Tests.

The ignition coil is readily tested by the test points. The primary circuit is tested between the terminals on the top of the coil at the rear. The secondary winding can be tested for open circuit by testing from the high tension terminal to either of the other terminals (see page 402). The test lamp will not burn when making this test on account of the high resistance of the secondary winding, but a spark can be obtained when the test point is removed from the terminal. No spark will be obtained if the winding is open.

A short circuit in the secondary winding, causes the spark obtained from a wire removed at the plug to be much weaker and will cause missing when the engine is pulling, especially at low speeds.

To Test Accuracy of Ammeter.

Should the charging rate appear to be abnormally low with no apparent reason it is a good plan to check the ammeter by connecting another meter in series with it.

Reliable meters may become defective as automobile service is extremely hard for a sensitive ammeter—see page 410.

Testing Light Circuits.

See pages 403 and 416.

**Principle of the Volt-Ammeter.

A voltmeter and an ammeter, or a combination volt-ammeter is one of the most important instruments that the mechanic can use in this work, and in order to explain the action of such a meter, see fig. 10. This shows the internal circuits of such a meter with full scale readings of—30 amperes, 3 amperes, and 15 volts.

The meter proper consists of a permanent magnet "M" between the poles of which is mounted a movable coil "K" which carries the pointer. **This** part of the meter is very sensitive and carries only a small amount of current.

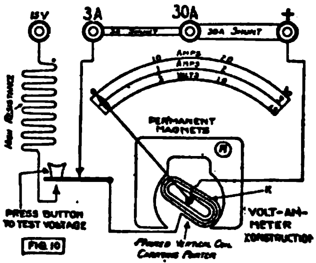

15V
3A
30A
+
3A SHUNT
30A SHUNT
AMPS
AMPS
VOLTS
10
20
1
2
5
10
HIGH RESISTANCE
PERMANENT MAGNETS
M
K
PRESS BUTTON TO TEST VOLTAGE
VOLT-AMMETER CONSTRUCTION
PIVOTED VERTICAL COIL CARRYING POINTER

FIG. 10

---

*Cut-outs are not used on the late Delco system.

†See also page 284, 302.

**See also pages 414, 416, 410, 402, 453.

****When instrument is used as an ampere meter:** In the average meter with the scale readings as given, the current in the different parts would be approximately as follows:

With the meter connected to give a full scale reading of 30 amperes (connect the lines to the terminal marked + and to the one marked "30-A"), the current would divide at the + terminal, the main part of which flows to terminal marked "30-A" 29-9/10 amperes flowing in this circuit, and 1/10 amperes flowing through the coil to terminal 3-A, through the shunt to 30-A terminal. The 1/10 ampere through the movable coil is the amount required to give a full scale reading of the pointer.

When the 3 ampere scale is used the current divides at the + terminal and 2-9/10 amperes flows through both shunts to 3-A terminal, and 1/10 ampere through the coil as before. The difference in the proportions of the total current that flows through each circuit, from the amount that flows through each circuit in the former case, is due to the resistance of the 3-A shunt.

Voltmeter: When the instrument, (fig. 10) is used as a voltmeter, connections are made to the positive terminal and the terminal marked "15 V" and the button must be pressed. This cuts out the shunts and connects in series the high resistance. This is a very high resistance and when the full voltage reading is taken there is 1/10 of an ampere flowing through the high resistance and the movable coil, which is the same amount of current that flows in it when it is used as an ammeter and it gives a full scale deflection—see also page 410, 414.

The important points to remember when using an instrument of this kind are as follows:

1. **Do not test the storage battery with an ammeter** as dry batteries are tested. (This will positively ruin the meter).

2. **In taking an ammeter reading in the circuit** where the approximate flow of current is not known, **always use the highest scale on the meter** and make the connection where it can be quickly disconnected in the event of a high reading.

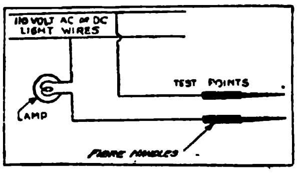
3. **If the meter reads backwards reverse the wires to the meter terminals.** The meter will not be damaged by passing a current through it in the reverse direction as long as the amount of the current is not over the capacity of the meter.

4. **No damage will be done by connecting a voltmeter as an ammeter,** so long as the voltage of the system is not above the range of the voltmeter, but the ammeter should not be connected as a voltmeter.

5. **A high-class instrument of this type will stand a momentary overload of from 200 to 400%.** If the user is careful not to make his connections permanently until the current is normal, he will very seldom injure the instrument.

*Test Points.

Next to the combination volt-ammeter the most important testing arrangement for the mechanic is a set of "test points" to use in connection with the electric light circuit. This is very easily made by tapping one wire of an ordinary extension lamp, splicing the wires onto suitable points with insulated handles in order that these may be handled with no danger of electrical shock.



The circuit is shown in illustration. With a set of test points as described the **lamp will burn when the test points are together or when there is an electrical connection between the points.**

This will give more satisfactory results for testing for grounds, leaks or open connections than will a bell or buzzer used with dry batteries, as the voltage is higher and it requires a small amount of current to operate the lamp. With a bell or buzzer, a ground or open connection may not exist, but the resistance is so high that enough current will not be forced through it by the dry batteries, to operate the bell or buzzer.

No harm can be done to any part of the Delco apparatus by test points as described above, when the ordinary carbon or tungsten lamp is used in testing purposes.

Motoring the Generator, Principle, Troubles and Tests.

As stated on page 386, the motor-generator performs three distinctly different functions; that is: 1—motoring the generator, 2—cranking the engine, 3—generating electric energy.

Whenever an armature is revolved within a magnetic field a voltage is induced in the armature winding. On a motor, this voltage opposes the voltage of the applied current, and is termed "**counter electro-motive force.**"

When the ignition button is first pulled out and the armature is not revolving, there is of course no voltage being generated, therefore a comparatively heavy current flows. After the armature commences to revolve this current decreases, due to the "counter-current" induced in the armature opposing that of the battery. Thus it can be noticed that the first reading of the ammeter will be much more than the reading after the armature is turning freely.

†**The "motoring" of the generator is one of the most important operations for the mechanic to familiarize himself with,** as the same wiring and parts of the generator are used during this operation as when generating. Therefore, if the apparatus will perform this operation properly, it is very sure to generate when driven by the engine.

---

*See pages 403, 418. †See also pages 386 and 387. **To test an ammeter for accuracy see pages 398, 410.

Principle of a Motor.

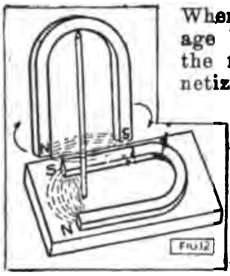


Fig. 12. Magnets will rotate, until "unlike" poles come to rest, near as possible to each other.

When current from the storage battery flows through the field winding it magnetizes the pole pieces and creates a magnetic field between them, in which the armature revolves. Without going too much into technical detail we will simply state that whenever a current of electricity flows through a wire there is a magnetic "field of force" created around it, see page 221, and if this wire be formed into a loop, or closed coil and is placed in the "field of force" flowing between the poles of the motor—it swings around in exactly the same manner as a compass needle or two magnets (as in fig. 12) and will rotate until the unlike poles come to rest as near as possible to each other. This single loop will swing around until it places itself parallel with the lines of force that are flowing from N. to S. pole and there it would come to rest or "dead center."

To overcome this dead center point it is necessary to have more than a single loop on the armature which you know is always the case. Each loop in turn tries to place itself in this parallel position and in so doing, helps pull the one already there away, due to the fact that they are all on the same revolving piece.

In a motor there is no current in any of the armature coils except those coils with ends fastened to the particular commutator segments that happen to be under the brushes. Each in turn receiving current as it comes under the brush.

During the motoring of the generator the pole pieces are magnetized by the current through the shunt field winding. The armature is magnetized by the current through the brushes and generator winding on the armature. It is necessary that current flows through both of these circuits before the armature will revolve. It is a familiar mistake to think that when current is passing only through the armature the armature should revolve. The shunt field current can be easily checked by disconnecting the shunt field lead from the generator at the ignition coil terminal.

Ammeter reading when "motoring" generator: The ammeter in this line should indicate approximately 1¼ ampere when the ignition button is pulled out. The ammeter on the combination switch can be depended upon to determine the amount of current flowing through the generator winding during this operation. Both the ignition current and the shunt field current flow through this meter in addition to the current through the generator armature. The timing contacts should be open. This will cut off the ignition current and leave only the armature and shunt field current. Since the shunt field current is only 1¼ amperes the reading of the ammeter will readily indicate whether or not current is flowing through the generator armature.

Tests for "Motoring" Generator.

Should it be found that the current through both the armature and the shunt field windings is normal and the armature still does not revolve the trouble may be caused by either (1) the armature being tight mechanically, due to either a sticking driving clutch, trouble in the bearings or foreign particles jammed between the armature and pole pieces. This can be readily tested by removing the front end cover of the generator and turning the armature from the commutator; (2) the shunt field winding or the generator armature winding may be defective in some manner, such as shorted, grounded or connected to the motor winding. (See testing armature on page 402.) Any one of these would show an abnormal reading of the ammeter in some position of the armature when it is revolved by hand.

If the ammeter vibrates at each revolution of the armature during the motoring of the generator, and when the engine is running at low speeds, this is very conclusive proof that the armature has either a ground, open coil, shorted coil, or is connected to the motor winding.

In the generator windings each coil consists of 4, 5 or 6 turns of wire, depending upon whether the generator is to be driven at engine speed or one and one-half times.

*Cranking the Engine.

Cranking the engine is performed by the current from the storage battery which flows through the series field winding, the motor brushes and armature winding. This much being what is known as a "series" motor, but in addition to this the current flows through the combination switch and the shunt field winding on the generator, making what would be considered, strictly speaking, a compound motor for the cranking operation.

The shunt field current is not absolutely necessary for this operation, but is used because it increases the efficiency of the cranking motor. It can be seen by referring to the circuit, page 388, that the shunt field current would not be in use in the event of the cranking operation being performed when the iguition button is not pulled out.

****This cranking current is a heavy discharge on the storage battery, the average car requiring approximately ½ horse power to perform the cranking operation.** 9/10 of all cranking failures is due either to the storage battery or poor connections in the cranking circuit. The first rush of current from the storage battery during the cranking operation varies from 130 to 450 amperes, depending upon the condition of the engine and the storage battery. This is only a momentary flow of current, however, but **a poor connection prevents this heavy flow of current and prevents the starter from giving its full force.**

This heavy discharge will naturally cause the voltage of the battery to be decreased, and the amount that it is decreased, depends to a great extent upon the condition of the charge of the battery. On a storage battery which is charged so that its specific gravity registers 1200 or more the voltage should not fall below 5 volts on the voltmeter reading when cranking.

**See also pages 407, 427 and 327. See also page 386 on "cranking operation."

*Hints for Locating Delco Troubles—condensed.

1. **If starter, lights and horn all fail,** the trouble is in the storage battery or its connections, such as a loose or corroded connection or a broken battery jar.

2. **If the lights, horn and ignition are all O. K., but the starter fails to crank,** the trouble is in the motor generator, such as dirt or grease on the motor commutator, or the motor brush not dropping on the commutator.

3. **If the starter fails to crank or cranks very slowly, and the lights go out or get very dim while cranking,** it indicates a loose or corroded connection on the storage battery, or a nearly depleted storage battery.

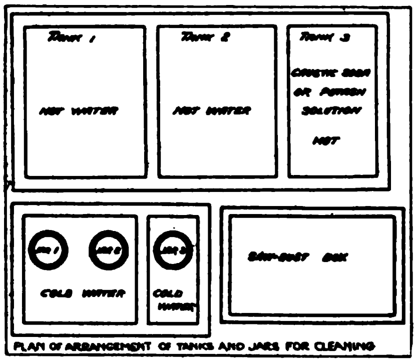
4. **If the engine fires properly on the "M" button, but not on the "B" button,** the trouble must be in the wiring between the dry cells or the wires leading from the dry cells to the combination switch, or depleted dry cells.

If the ignition works O. K. on the "B" button and not on the "M" button, the trouble must be in the leads running from the storage battery to the motor generator, or the lead running from the rear terminal on the generator to the combination switch, or in the storage battery itself, or its connection to the frame of the car.

5. **If both systems of ignition fail, and the supply of current from both the storage battery and dry cells is O. K.,** the trouble must be in the coil, resistance unit, timer contacts or condenser. This is apparent from the fact that these work in the same capacity for each system of ignition. (Does not apply to all Delco systems.)

Instructions for Cleaning Repair Parts of Delco Apparatus.

The cleaning outfit should consist of three, sheet steel tanks, of suitable size (preferably about 35 gallons), which are mounted in such a manner that the contents may be kept heated to the desired temperature; three stone jars of approximately 15 gallons capacity; and a sawdust box.



PLAN OF ARRANGEMENT OF TANKS AND JARS FOR CLEANING

Two of the steel tanks should be equipped with overflow pipes so that they can be kept about two-thirds full at all times. These will be spoken of as tank No. 1 and tank No. 2. They are used for clear, hot water for rinsing the apparatus after it has been cleaned. A supply of water should be available, so that this water can be kept as clear as possible.

The third tank does not need either a drain or overflow pipe and should be used for the potash or caustic soda solution. This solution can be used for a long time without changing it by simply adding a small amount of potash or soda as the solution is found to be weakened. All three tanks are maintained at a temperature of from 180° to 212° (degrees) Fahrenheit, or approximately at boiling point.

The three jars mentioned above are to be used for the acid solutions and will be spoken of as jar No. 1, jar No. 2, and jar No. 3 respectively.

A wooden tank should be provided which is large enough to permit the three jars to be set in it and also to carry a supply of clear, cold water. This tank should also be divided so that jars No. 1 and No. 2 are in one division and jar No. 3 in the other. This is very important, as the work cannot be rinsed in the same cold water bath after being immersed in these various solutions. The sketch shown in figure will give an idea of the outfit.

The solutions recommended are as follows: In tanks one and two, clear, hot water; in tank three, a solution of Potash or Caustic Soda, which is made by mixing one pound of Potash or Caustic Soda with one gallon of water.

The jar No. 1 is filled with a solution made up carefully of the following formula: four gallons of Nitric Acid; one gallon water; six gallons sulphuric acid. The water is placed in the jar first, the nitric acid is added slowly and the sulphuric acid is poured in last. This order should be very strictly observed, as it is dangerous to attempt to mix up a solution of these acids in any other manner.

The solution in jar No. 2 is made up with the following formula: one gallon Hydro Chloric Acid to three gallons of water. Jar No. 3 is filled with the following solution: one-half pound of Cyanide to one gallon of water.

Tank No. 2 should be used for parts which have been in the Potash solution and for no other purpose; tank No. 1 for general rinsing.

Cleaning Various Metals.

Steel is boiled in the Potash solution until the dirt is removed. This should take only a few minutes. It is then rinsed in tank No. 2 and dried in sawdust.

Cast Iron is boiled in the Potash solution until dirt is removed, rinsed in tank No. 2, dipped in the acid solution in jar No. 2, rinsed in cold water, rinsed in tank No. 1 and dried in sawdust.

Brass is boiled in the Potash solution until the dirt is removed, rinsed in tank No. 2, dipped in the acid solution in jar No. 1 rinsed thoroughly in clear, cold water, dipped in the cyanide solution, rinsed in clear, cold water, rinsed in tank No. 1, dried in sawdust. Copper can be cleaned in the same manner.

Polished aluminum should first be thoroughly washed in benzine or gasoline, rinsed in tank No. 1, dipped in the acid solution in jar No. 1, rinsed thoroughly in clear, cold water, rinsed in tank No. 1 and dried in sawdust.

Plain aluminum (polished), should be dipped in the Potash solution, rinsed in tank No. 2, dipped in the Potash solution, rinsed in tank No. jar No. 1, rinsed thoroughly in clear, cold water, rinsed in tank No. 1 and dried in sawdust.

Plain aluminum, (not polished), should be dipped in the Potash solution, rinsed in tank No. 2, dipped for a few seconds in the acid solution, rinsed in tank No. 2, dipped for a few seconds in acid solution in jar No. 1 rinsed, thoroughly in clear, cold water, rinsed in tank No. 1 and dried in sawdust.

It will be noticed when the aluminum is put in the Potash solution that the metal is attacked or eaten away very rapidly. Care should, therefore, be taken not to leave the work in this solution any longer than is absolutely necessary. In cases where the work is covered with caked grease or has hard grease deposits on it, these pieces should first be washed in benzine or gasoline. Aluminum parts should never be washed in the Potash or Soda solution unless they can be put through the acid immediately after. The acid dip is used to neutralize the effects of the Potash solution. Parts should only be held in the acid solution for a few seconds.

Paint on aluminum should be removed with a good varnish or paint remover, unless it is a very small quantity and the work is to go through the Potash solution.

With regard to enameled work, it is recommended that it be washed with soap and water, dried thoroughly and then polished with a cloth dampened with three in one or O'Cedar oil.

The methods described above are for solid metals only and should not be used on any plated materials. Practically all Delco clips are tinned and should be cleaned, therefore, in benzine or gasoline. All plated parts should be cleaned in benzine or gasoline.

---

*See also pages 377, 398 and 400.

*Testing Delco Motor-Generator Armature.

Test points, per pages 399 and 418 are used in connection with a lamp for part of the tests **and a combination volt-ammeter** is used for the other tests shown on this page.

It is not necessary to remove the motor-generator from car. Where there are grounds in armature winding, or short-circuits **between** them or short-circuits between generator and motor armature winding, simply raise brushes and insulate them from commutator with pieces of cardboard.

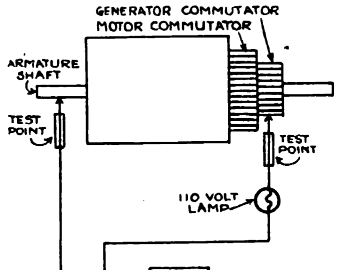


FIG. 1

Armature Tests with the Test Light for Grounds.

Fig. 1. A grounded generator armature coil will result in slow cranking and materially reduce the charging rate. (Note **armature** and generator winding is on one armature in this particular system.)

To test to see if armature coil is grounded see fig. 1. If lamp lights, a ground is indicated.

Fig. 2. A grounded motor armature coil will cause excessive amount of current to be drawn from battery while cranking, or prevent cranking entirely (meaning of the word "cranking" is explained on page 400).

To test to see if grounded. see fig. 2. If lamp lights, a ground is indicated.

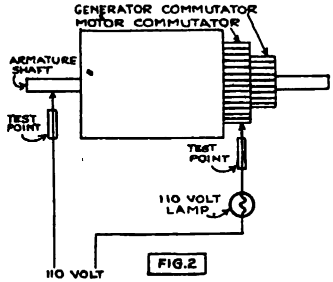


FIG. 2

Fig. 3. Short circuits between motor and generator armature coils will decrease speed of cranking and also cause armature to continue to run after engine is shut down.

To test, see fig. 3. If lamp lights a short circuit between motor and generator armature coil exists.

Armature Tests with the Volt-Ammeter for Open-Circuited and Short-Circuited Armature Coils.

Testing for open and short circuited armature windings with a volt-ammeter. Before proceeding, turn to pages 414, 416 and study the construction of the Weston model 280 volt-ammeter, which is used in the following tests.

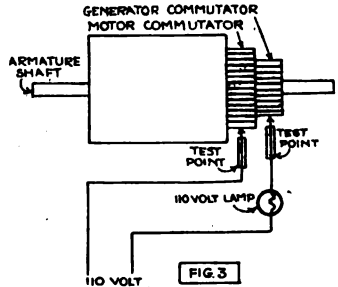


FIG. 3

Fig. 4. Open or short circuited generator armature coils. The generator brushes should be left on contact with commutator, but **disconnect storage battery from system.** Then connect a dry cell as shown; one connection to the 30 ampere shunt and the other to the brushes, see page 414 for meaning of "shunt."

To test, turn armature slowly by hand. If commutator is in good shape and brushes are making good contact, the ampere reading should be the same in all armature coils—when brushes make contact with the different coils through the commutator segments, but if a very noticeable **change** in the ammeter reading takes place while turning, this will indicate an open or short-circuited armature coil.

Fig. 4.

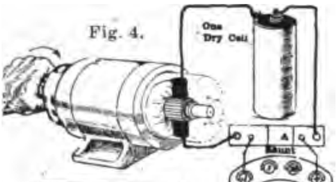


Fig. 5. To then tell if generator armature coil is open-circuited or short circuited proceed as follows:

To test for open-circuited coil, connect brushes on commutator to a dry cell as per fig. 5, so that about 1 ampere will flow through the brushes. The field winding should be disconnected. Then connect test points to the 3 volt scale of meter and measure the voltage across two adjacent commutator segments. The readings should be the same, as the test is made on all commutator segments, but if there is a material **increase** in the reading on any two segments, then there is an open circuited coil.

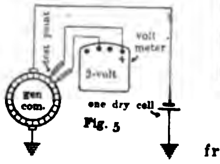


Fig. 5

Fig. 6. If there are no open circuited armature coils but the test per fig. 5 shows there is some armature trouble, then test for a short-circuited coil. This, however, should only be done after making the test per fig. 5, as we will now use the .1 volt scale of meter, and if there was an open-circuited coil, the voltmeter might be burned out if this test was made first.

To test for a short-circuited armature coil—see fig. 6. Connect test points on meter with the one-tenth volt (0.1) terminal and the + terminal—see also page 414. Turn armature slowly by hand and test each adjacent commutator segment as shown in fig. 6. If on testing any of these coils, the reading drops to zero, it will indicate that one or more of the armature coils are short-circuited.

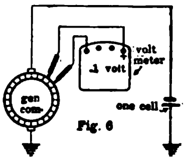


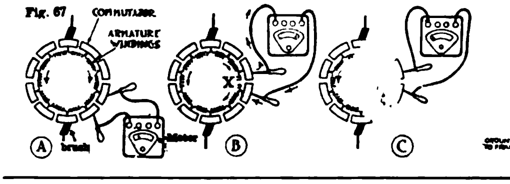
Fig. 6

Fig. 67: These diagrams will explain what is meant by an open and short circuited armature coil. A, shows diagram of commutator with brushes which make contact with segments and carry the current during the test. It will be seen that the current **divides equally** from upper brush, passing down each side of the armature coils, or winding circuits, and out at the lower brush, and **if in good condition** the voltage between two commutator segments will be the same.

If an open current in one of the coils, as at X fig. 67, (B), there will be an interruption of current flow on that side, and if test-points are placed on the two segments shown there will be a big **increase** of needle since meter will carry **all** of the current flowing down that sidu. If points are placed on adjacent segments on that side, there will be a zero reading.

If a coil is short-circuited, per Y, fig. 67, (C), the meter, if placed on the segments shown will be zero, the short circuit having the effect of a shunt across meter.

Fig. 67



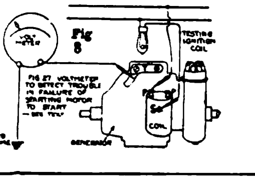


Fig 8
TESTING IGNITION COIL
FIG 87 VOLTMETER TO DETECT TROUBLE IN FAILURE OF STARTING MOTOR TO START —SEE TEXT
GROUND TO FRAME
GENERATOR
COIL

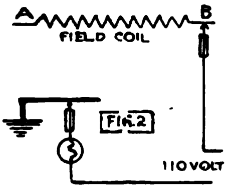
Testing Ignition Coil

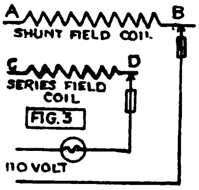
Fig. 8. In this instance it is placed along side of th motor-generator. To t place one "light test pc on secondary termin·at and other on prim the see page 398 f··arged ion—see also p·or more 302 for other d on the

CHART NO. 188-I—Testing Delco Armatures. *Although these tests apply to the they will also apply to many other systems. See also pages 414, 416, 410, 406,

Testing The Delco Motor-Generator Field Coils.

Fig. 2: To test for grounds in the field coils of motor generator, place one point on frame of motor-generator, the other, on terminal of field coil.





Be sure all grounds which are regularly connected to these terminals are first removed.

If lamp lights a ground is indicated. If it **fails to light** coil circuit is o. k.

Fig. 3: To test for open circuits in the field coil, place test points as shown, on each terminal of the winding.

If lamp fails to light the circuit is open. The coil should be replaced or repaired.

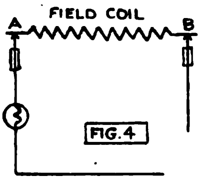


Fig. 4: To test for short circuits between motor-generator windings; the test here is between the "shunt" and "series" field winding.

Place one of the test points on the terminal of one of the field windings and the other test point on terminal of other winding.

If lamp lights, a short-circuit is indicated between the windings.

Meaning of Grounds and Shorts.

A grounded coil is where the insulation is off the wire and it makes contact with metal.

A short-circuited coil generally applies to a field or armature with two windings on it and on which the insulation is off and in contact with each other.

Testing The Delco Wiring Circuit.

To test the wiring circuit for troubles, use the test points illustrated on page 399. Either direct current or alternating current can be used with 110 volt lamp placed in series.*

A typical single unit Delco wiring circuit is shown below. The tests however will apply to many of the other systems.

Parts Which Are Grounded.

It will be observed that certain portions of the circuit are grounded to the frame of the car. The battery terminal, the lamp return wires, one motor and one generator brush, one of the timer contacts, one terminal of the horn push button and one terminal of the condenser in the coil are grounded.

When Testing For Grounds.

First remove the grounded connections by disconnecting the **negative battery terminal from battery which is grounded to frame of car, and remove all lamp bulbs.

Then place a piece of cardboard between commutator and brushes of the motor and the generator (third brush also).

Disconnect the lead wire from the horn button and distributor and raise the base of the ignition coil so that it is insulated from the top cover of the motor-generator.

To Test For Grounds.

To test for grounds, see test No. 4; place one of the test points on the frame of the car and the other test point on the negative terminal of the battery (A).

If the lamp lights, then a ground is indicated and will likely be on the switch or in the motor windings (if all the switch buttons are pushed in).

Now with one of the points still grounded to frame of car, touch with the other point different terminals of the combination switch.

If lamp lights, then a ground is indicated and should be found and removed.

To Test For Short Circuits.

Testing for short-circuits between two wires which are supposed to be insulated from each other—see test No. 5; place one test point on one wire and the other point on the other wire.

If lamp lights, a short-circuit is indicated between the two wires.

If lamp does not light, then this portion of circuit is o. k.

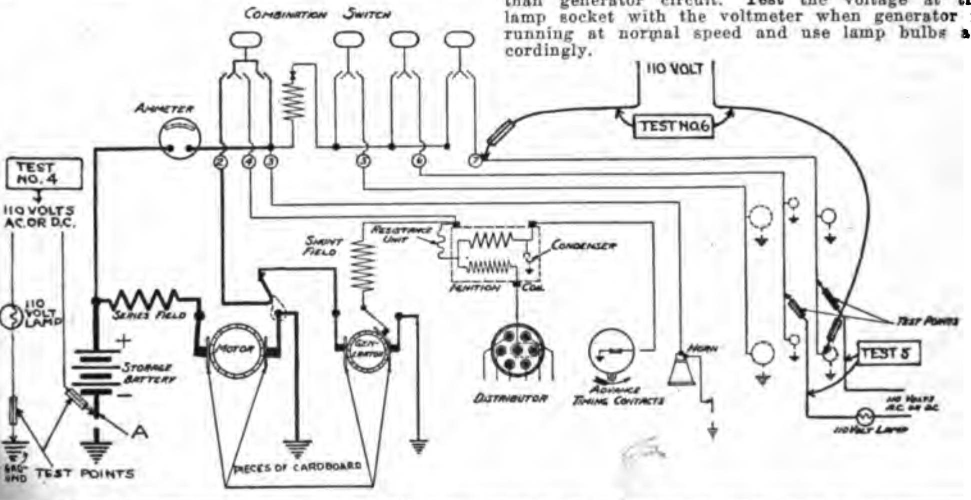
To Test For a Broken Wire.

To test for a broken wire—see test No. 6; place test point at each end of wire as shown.

If lamp lights, the circuit is complete. **If lamp does not light,** then there is a break somewhere between the two points. By gradually moving the test points towards one another, the break can be definitely located.

If Lights Burn Out Often.

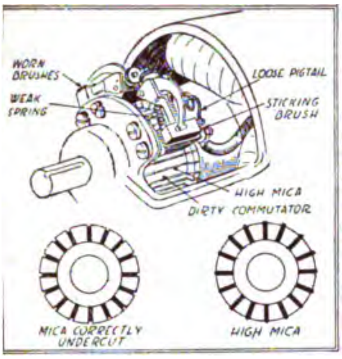
It is likely due to using a lower voltage lamp than generator circuit. **Test** the voltage at the lamp socket with the voltmeter when generator is running at normal speed and use lamp bulbs accordingly.



RT NO. 188J—Testing for Open Circuits in the Field Coils. Test Points for Testing Shor its Between Two Points. Testing for Grounds. See also pages 406, 418, 413, 416.

---

n using test light, it is advisable to occasionally bring both test points together or touch one with th r, to make sure that test light is still in working order, as very often the filament of lamp breaks owing t ough nature of test work and when this happens one is led to erroneous conclusions. **On many sys positive pole of battery is grounded.



ig. 3. Commutator and brush troules. Copper is softer than mica and ears more rapidly, until the mica is far above, that brushes cannot make ood contact. When this occurs, the ica must be undercut as shown at e lower left.

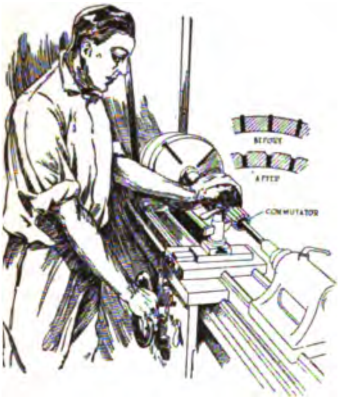
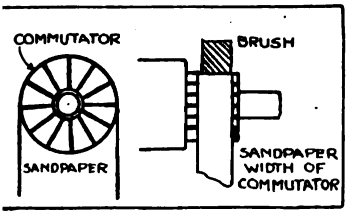
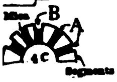


Fig. 4. Dressing commutator.



'ig. 5. Method of smoothing down a 'commutator'' with a strip of sand-paper and properly seating the 'brushes'' to the rounded surface of ommutator.



To cut the mica down; a three cornered file to start the groove in the mica, and a hack-saw blade with a handle on it and teeth ground on the side, can be used for cutting down the mica.

Note the mica must be cut square across, as at , and not leave a thin edge, as at A.

**Commutator Troubles.

Commutator troubles are: arcing at brushes, weak brush holder springs, loose pigtails or connections of wires to the brushes, sticking brushes, overloading of generator and short-circuits between the motor and generator windings.

Arcing at brushes is usually due to mica protruding above the commutator segments—see fig. 3, lower right illustration, "high mica."

The cause of mica protruding is due to the copper segments wearing down below the level of the mica as stated under fig. 3. The brushes then cannot make good contact, therefore arcing occurs and commutator burns and blackens and becomes rough.

This trouble is more common on generators. On starting motors, where brushes do not make good contact, the commutator becomes rough and causes arcing.

††Most of the troubles of this nature are due to the use of carbon brushes, which are not hard enough to wear the mica down. The "generator" commutator on the Delco therefore requires more care in this respect. The Delco "motor" commutator however, where metal brushes are used, the trouble is not so great, as they are harder.

To remedy protruding mica; remove the armature and very carefully true or dress it up on a lathe per fig. 4. Then cut out the mica between the bars with a hack saw blade, the sides of its teeth having been ground off so that it will cut a groove slightly wider than the mica insulation, per fig. 4B. This will leave a rectangular groove free from mica; the depth should be about 1/32 inch.

The edges of the slots should then be slightly beveled, using a three-cornered file, in order to prevent any burrs remaining, which would cause excessive brush wear.

When properly finished commutator will have the appearance of illustration, fig. 4 "after." See also pages 409, 406.

Note. The mica can also be cut by placing a special tool in the lathe and moving it laterally as a planer—fig. 4 as suggested by Motor World.

The blackened and burned appearance of the commutator is not always caused by high mica. The same effect may be caused by having brushes of improper size or material, by an insufficient spring tension on the brushes, by an overload on the generator and by an open or short circuit in the generator windings, or where there are two windings on one armature with two commutators, by a short-circuit between the motor and generator windings. (from Weston Inst. book.)

†Commutator Noises and Cleaning Commutator.

If it makes a noise and trouble is not from the protruding mica, the commutator can be cleaned by speeding engine up to about 1000 r. p. m., then wipe off commutator with a piece of cloth dampened with gasoline to remove grease and dirt—or new brushes fitted.

If commutator is rough, smooth down with sandpaper cut a little wider than the brush and wrapped around the commutator so as to make contact with at least half of its circumference, as per fig. 5. Use 00 fine sandpaper—never use emery cloth. Don't lubricate, see page 406.

Noise can also sometimes be eliminated by slightly setting the brush to one side with a small wood stick—never use a screw driver or metal.

Fitting Brushes.

***The brush must always make good contact with the commutator;** they should have sufficient spring tension to press the brush to the commutator, yet move freely.

When fitting new "generator" brushes, they don't always fit the commutator perfectly, that is, they are not rounded to the commutator surface. This can be remedied by placing the rough side of a strip of grade 00 sandpaper **under the brush, when it is in its brush holder** (each brush separately), and work the strip back and forth holding the ends close together as per fig. 5, so it will conform with the curvature of commutator. The entire surface of the brush must be treated, otherwise it will be uneven. The "pig tails" or brush connections must also be kept tightened.

When fitting "motor" brushes to Delco armature, the same method is applicable, but something harder than sandpaper must be used. A strip of carborundum cloth can be used on the "motor-brushes," but sand cloth on the "motor-commutator." It is seldom necessary to cut mica down on the motor-commutator. See page 406 for cleaning brushes.

When Starting Motor Fails to Start.

the armature fails to start when pulling out the ignition button, the trouble may be due to: (A) weak orage battery; (B) switch contacts defective; (C) the clutch may be sticking; (D) armature shaft out alignment; (E) bearings of generator defective; (F) waste or foreign substance between armature and ole pieces; (G) generator brushes not making good contact; (H) loose, dirty connection, ground or short rcuit.

RT NO. 188K—Commutator and Brush Troubles. When Motor Fails to Start.

foot note page 407 and next to lower right paragraph, page 400. **See also page 409. †See page 325 ind of brushes used on starting motors and 408 generator brushes. ††See foot note page 405.

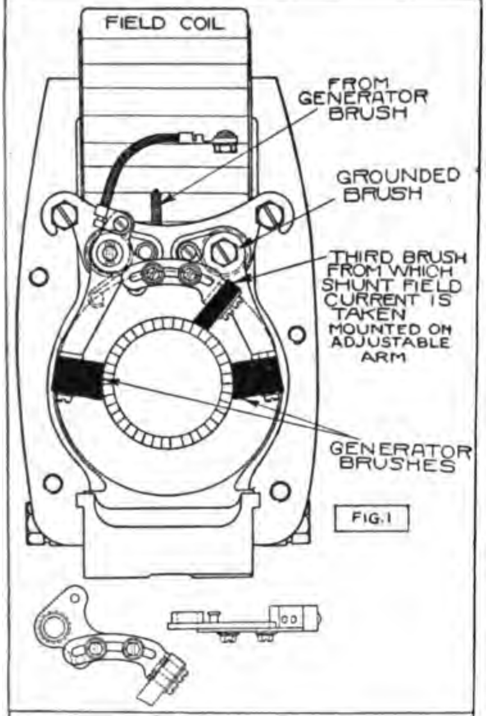
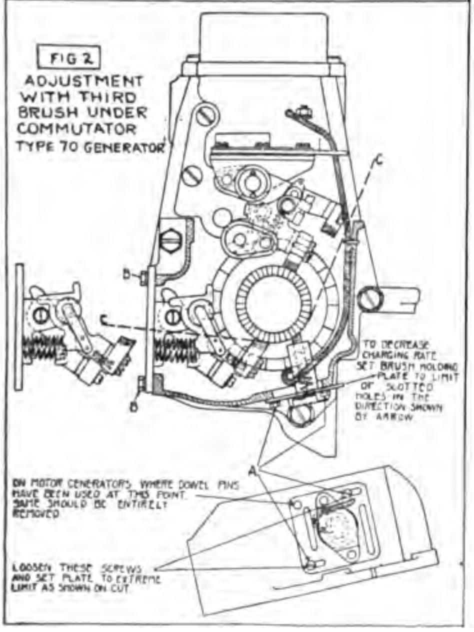

FIELD COIL
FROM GENERATOR BRUSH
GROUNDED BRUSH
THIRD BRUSH FROM WHICH SHUNT FIELD CURRENT IS TAKEN MOUNTED ON ADJUSTABLE ARM
GENERATOR BRUSHES

FIG. 1

FIG 2. ADJUSTMENT WITH THIRD BRUSH UNDER COMMUTATOR TYPE 70 GENERATOR


C
B
C
B
TO DECREASE CHARGING RATE SET BRUSH HOLDING PLATE TO LIMIT OF SLOTTED HOLES IN THE DIRECTION SHOWN BY ARROW
A
ON MOTOR GENERATORS WHERE DOWEL PINS HAVE BEEN USED AT THIS POINT SAME SHOULD BE ENTIRELY REMOVED
LOOSEN THESE SCREWS AND SET PLATE TO EXTREME LIMIT AS SHOWN ON CUT

Adjustment of Delco Third Brush.

There are two arrangements of the Delco third brush; over commutator and under commutator: The third brush is supported on an arm which is arranged to lengthen or shorten by means of screws and slots in this arm. In the single unit system, using generator No. 70, and on all the two-unit systems, the third brush is located on the lower side of the commutator, and is mounted on a plate which is arranged to move to obtain similar results.

The moving of this brush in the direction of rotation increases the charging rate and moving the brush in the opposite direction, of course, decreases the charging rate. These generators leave the factory adjusted to give ample charging rate for the average driver.

If the car is driven a great deal and the lights and starter used comparatively little, it is possible to overcharge the storage battery unless the charging rate is decreased.

The overcharging of the storage battery is indicated by the rapid evaporation of the water, and occasionally a too frequent burning out of the lamps. Therefore for this type of drivers it is advisable to decrease the charging rate by moving the third brush in the opposite direction from that in which the armature rotates. If this brush is moved, it is necessary to draw a piece of fine sand paper (with the sand side next to the brush) between the brush and the commutator a few times.. If this is not done the brush will not make good contact, and the charging rate will not be as high as when the brush is well seated.

With the type of driver who uses his car a great deal at night and drives a very little in the day time it is advisable to have a higher charging rate than these generators develop with the factory adjustment. With this type the third brush should be moved in the direction of rotation of the armature, and the brush sanded as described above. When the charging rate of the generator is increased, it is always essential that the charging rate be carefully checked up by use of the ammeter on the combination switch, and in no case should this exceed 20 amperes to any extent unless it is positively known that the driver never operats his car at fairly high speeds, excepting for short runs. Checking of the charging rate, should be obtained after the brush is well seated and the engine is gradually speeded up, observing the maximum charging rate indicated on the ammeter. This test should be made when all the lights are off.

To adjust the Delco third brush over commutator: By reference to the accompanying figure, it will be noted that the third brush is mounted on a brush arm, which is made up in two pieces. The part to which the brush is fastened has a slot through which pass two screws, attaching it to the other part. By loosening these screws it is possible to slide one part upon the other, and so increase or decrease the length of the arm.

When the arm is shortened, the charging rate is decreased, and the reverse is also true. Care should be taken to sand in the third brush carefully every time it is shifted, so it will have good contact with the commutator. (See instructions for "seating motor and generator brushes.") The screws on the brush arm should be tightened firmly after a change has been made, in order to prevent slipping.

The charging rate should rise to its maximum at a car speed of from fifteen to twenty miles per hour, and then drop off as the speed increases beyond this point.

In order to change the charging rate on the 70-motor-generator it becomes necessary to shift the third brush on the generator commutator. **To reduce the rate, shift** the third brush bracket plate in the direction indicated by the arrows on the accompanying cut.

To shift this brush bracket plate, loosen two screws "A" fig. 2, shown in the cut, and shift plate in the direction indicated by the arrow, to the full extent permitted by the slotted holes receiving the **screws marked "A."**

Note—The charging rate should be limited to 12 to 14 amperes with lights off. In case the charging rate cannot be sufficiently reduced, it may be necessary to lengthen the holes in the brush bracket plate with a file. After the brush is shifted it will be necessary to carefully sandpaper it so that it fits perfectly.

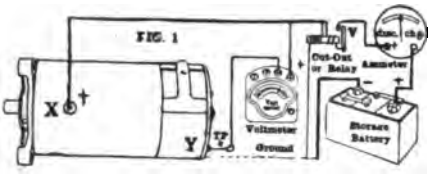
Carbon brushes are used on all Delco generators because they give better commutation and are porous, which allows lubricants to be forced in them, making them self-lubricating.

The copper composition brush is used on all Delco starting motors because the carbon brush has too high a resistance to carry the high cranking current required. The copper or composition brush has a high carrying capacity and smaller brushes can be used.

CHART NO. 188L—Adjustment of the Delco Third Brush for Charging Rate.

Testing for Dirty or Rough Commutator with Voltmeter.

Fig. 1. Connect voltmeter terminals, 0 to 30 volts as shown. (The construction of this Weston voltmeter is shown on page 414).



The positive (+) terminal of voltmeter is connected to the positive (+) wire of the generator. The other terminal from voltmeter which has a test point (TP) at its end, makes contact with the frame of generator at Y (this being a grounded or return wire system).

Then speed engine up to a speed corresponding to a car speed of 10 to 15 miles per hour. **The voltmeter should show slightly over 6 volts** and the cut out (V) should be closed, showing "charge" on the dash ammeter or indicator.

If voltmeter does not show slightly more than 6 volts, this indicates a dirty or **rough commutator**, or else an **open circuit** in the shunt field. Press down lightly on the brushes while the generator is running, and if this causes the voltmeter to indicate and the cut-out to close, the trouble is due to **bad brush contact**, which can be remedied as just mentioned.

If voltmeter cannot be made to indicate and the cut-out point (V) to close, by cleaning the commutator and pressing on the brushes, the trouble is probably an open circuit in the shunt field winding, which will have to be repaired locally or sent to the factory.

If the voltmeter does show 6 volts or more, by pressing down on the brushes, or by cleaning the commutator and brushes, but the cut-out will not close, it means that the cut-out is not in proper adjustment, and a new one should be provided if it is defective internally. The trouble may be due to loose connections on the cut-out, or disarrangement of the contact-points on V, which can be examined and tested per page 410 and 409.

To Clean Commutator.

See page 404, fig. 5 and also page 409.

If commutator is too rough to smoothe down with sandpaper, then it should be dressed down on the lathe and probabilities are the mica is protruding which can be remedied as explained on pages 404 and 409.

To Clean The Brushes.

It is not necessary to remove them from the holders. Lift the brushes and wipe off the surface with a piece of cloth dampened with gasoline.

If the brush surface is apparently rough then use sandpaper to fit them to commutator, per fig. 5, page 404.

No lubricant is to be used, as the brushes are usually self-lubricating. Application of vaseline or grease is harmful, as all forms of grease possess insulating qualities to a greater or less extent.

Test For Grounded Brush Holders.

Fig. 3: Use the 0 to 30 volt scale of voltmeter. Connect as shown and place one test point (TP) on armature shaft and the other on brush holder. If an indication is obtained, the brush holder is grounded.

Test For Grounded Armature and Field Coil.

Fig. 3A, grounded armature: Use the 0 to 30 volt scale of voltmeter. Connect as shown. One test point (TP) connects with each commutator segment, the other with shaft of armature. If an indication is shown, there is a ground between the coil connected with that commutator segment and the armature core. The cause of the ground is very likely due to damaged insulation on the wires. The armature should be examined carefully. A grounded armature coil will result in a reduced output.

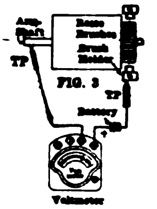


FIG. 3

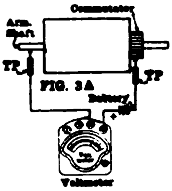


FIG. 3A

A grounded field can be tested by transferring the **connection** from the commutator **segment** to one end of the field winding. If a deflection of needle is obtained the field is grounded. Be sure the ends of field coil are not touching the frame of generator or motor—see also pages 416 and 403.

To test for an open circuit in field winding, see page 416 and 403.

Tests at Battery Terminals for Grounds and Short-Circuits in Different Parts of the Electric System

(a) Disconnect wire at generator and starter.

(b) Disconnect one terminal of battery—fig. 5.

(c) Connect these wires (which are disconnected) to one terminal of ammeter, using the 0 to 300 shunt (see page 414).

(d) Connect a piece of wire to the other terminal of ammeter and hold this wire (A) in the hand, ready to touch the battery terminal (B).

(e) **Disconnect starter and generator, open all lighting switches and ignition switch.** Touch ammeter wire A, to battery terminal B. If ammeter registers any current, no matter how small—**a ground in wiring system of car is indicated**, somewhere between battery, generator or starter. If ammeter shows a **heavy** discharge—**a severe short circuit is indicated.**

(f) **Reconnect wire at generator** and touch wire A to battery terminal B. If ammeter indicates current—**very likely due to cut-out points being stuck.**

(g) **Disconnect generator again, and remove all lamps from sockets**, then turn on each lighting circuit separately and note indication of ammeter after touching A to B. **If ammeter registers current** when either switch is turned on—**there is a short-circuit or ground in that particular circuit.**

(h) **To test for short-circuit in starter.** Replace wires to starting motor, turn on the ignition switch and press starting motor switch. See explanation under "test A2," page 410. A short-circuited starting motor will be indicated by slow turning and possibly smoke coming from the winding. The battery must be fully charged. Use only the 300 ampere shunt on these **tests—see page 414.**

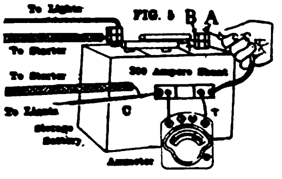


FIG. 5

CHART NO. 189—Testing For Defective Commutator. Cleaning Commutator and Brushes. Tests at Battery Terminals for Short-Circuits. See also pages 416, 410, 411, 402, 403, 418.

The meter used in these examples is the Weston, page 414.

INSTRUCTION No. 29.

*CARE, ADJUSTMENTS AND TESTS OF ELECTRIC STARTING, GENERATING AND LIGHTING SYSTEMS: Care of Starting Motor. Locating Starting Motor Troubles. Care of Generator; cleaning and adjusting commutators, brushes, armature troubles, etc. Testing Armature and Field Windings; short circuits and open circuits. Miscellaneous Troubles and Tests. Ammeter and Voltmeter; how to read and test with. Shunts, etc. Electrical Testing Outfits. A Digest of Lighting Troubles, etc.

Care of the Starting Motor.

The starting motor. Any trouble developing in starting motors, such as grounds, short circuits, brush and commutator troubles, will be taken up in detail under care of lighting and generator systems, and apply here.

The starting motor, is used very little in comparison to the generator; therefore it does not require the attention which the generator does, if it is a separate unit.

Oiling: Each of the oil cups should be given three or four drops of oil about once every two weeks. Use best machine oil.

The gear case of a geared motor (if gear case is an integral part), should be filled with a good quality of heavy oil; always first, drain old oil, and don't use more oil than called for.

Commutator: Keep commutator free from dirt cleaning when dirty, with a cloth (not waste). When commutator and brushes are in good condition it will show a glaze and commutator will be chocolate brown in color. If rough, smooth up with fine sandpaper as per chart 188K and 189, don't use emery paper and note in using sandpaper, strip must be width of commutator and must be held down as far around commutator as possible. Be sure and remove all grit and dirt, see chart 189.

****The brushes** should not be disturbed until you are sure trouble exist in them. If worn, get a new set. Keep the brushes in perfect contact with commutator. One of the greatest troubles with brushes is poor brush contact with commutator, on account of insufficient spring tension. Clean all dust from brush holder case with compressed air. See page 404, 406, 408.

†**Starting switch:** for flywheel application, the moving contacts should touch both stationary contacts during the first part of the motion. The adjustments of switch should be carefully investigated if the motor gives trouble. See pages 326 and 331.

Locating Starting Motor Troubles.

Only when you have made sure that the wiring is in perfect condition and that everything is connected up according to the wiring diagram should trouble be looked for in the electrical instruments themselves.

Surprisingly few troubles have been experienced with starting systems and of the troubles that have occurred, by far the greater part have not been due to the electric starting system, but to the carburetion or ignition, as failure of gasoline, carbonized spark plugs, etc. Therefore, first see if the ignition and carburetion are o. k.

If the starting motor fails to start when starting pedal is pressed down as far as it will go, test out the trouble as follows:

(a) Battery weak or discharged. Test battery with hydrometer or throw on lights (starting switch off) and note if dim—if so, battery is weak. If lights are bright then the probabilities are, the battery is o. k. also see chart 190, showing how the volt-meter is used to detect the cause or failure of starting motor.

(b) Look for an open circuit (broken wire) or loose connection in the wire from battery to starting switch, from switch to starting motor, from motor to ground, from ground to battery.

(c) See that the brushes and commutator are in good condition, and not sticky with oil and brush sets firmly on commutator. (see also page 331).

If motor with flywheel application:

(d) Press the pedal slowly so as to close the contacts, then motor should turn if battery, motor, and all connections are all right. See page 326.

(e) Examine the switch lever and switch adjustments and see that they have not worked loose in such a way that the switch does not close.

If sometimes the gears mesh and the motor runs satisfactory, and at other times it is impossible to mesh the gears, the motor refusing to turn when the contacts are closed, it indicates the possibility of an open circuit in switch or starting motor.

---

*This instruction applies to all systems in general. The Delco tests (Instruction 28-O), will also apply to some of the different systems.

****Owing to the high volume of current carried through starting motor brushes,** if worn or not properly adjusted, the commutator may become pitted and cause excessive wear—result failure of starting motor to operate properly or excessive sparking and weak motor. Remedy; take armature out and true up commutator on lathe (see page 404. See pages 325, 408 and 405, about kind of brushes used on starting motor and generator). †See page 408.

If engine does not pick up immediately after two or three trials though motor turns the engine over, the trouble is in: Either the gasoline supply; the spark plugs; the carburetor; or the ignition system.

If starting motor continues to run after the switch lever is released, see that the return spring on the switch or switch lever, is strong enough to return the parts positively and fully to the "off" position.

Failure of engine to start when starting motor is working satisfactory. This may be due to failure of gasoline or spark; test out as follows:

(a)—**Ignition switch,** examine to see if "on."

(b)—**See that there is gasoline in the carburetor.** If there is not, the gasoline may be used up, it may not be turned on, or the gasoline feed pipe or valve may be stopped up. If the system involves gravity feed, the gasoline may not flow into the carburetor on steep hills.

(c)—**If there is gasoline in the carburetor, take out one of the spark plugs** and lay it on the engine with the sparking point in the air while the engine is turned over by hand or by the starting motor. Also examine the spark plug points—they may be too far apart. 1/64 to 1/32 of an inch apart is about right. If a spark passes, the trouble is not in the electric system, but probably due to cold gasoline or need of priming.

If there is no spark, then see "Digest of troubles" and Index, and follow the diagnosis.

Summary of Starting Troubles.

Starting motor cranks engine very slow.—Battery almost discharged. ‡Battery sulphated. Engine stiff. Brushes loose and poor contact.

Starting motor does not rotate at all.—Battery may be discharged. Starting switch not making good contact. Motor brush may not make contact with commutator. Battery terminals may not make good contact. Switch contact poor.

Starting motor rotates but does not crank engine.—Roller clutch does not work properly. Gears not properly meshed. If Bendix automatic; spring broke. See page 331.

Starting motor cranks engine a few revolutions and then stops.—Battery weak—almost discharged. Loose switch contact. Engine stiff.

Starting motor cranks engine and will not pick up under its own power.—These symptoms indicate that trouble is not in the starting system. If Bendix starter; gear on threaded shaft stuck or spring broke.

***A weak starting motor is sometimes caused by using carbon brushes instead of metal composition brushes.** The latter have 3 to 4 times the conductivity, and for this reason their replacement by cheap carbon will not allow sufficient current to pass.

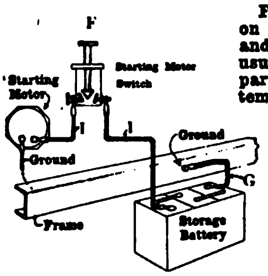
****If the battery is all right proceed to examine the connections,** beginning with the battery. The current may be shorted, due to electrolyte spilled over the top of it; or terminals may be sulphated, in which case enough resistance will be offered to the current to prevent proper operation.

Scrape off the sulphate, wash surrounding metal parts in carbonate of soda or some other alkali.

Clean battery terminals inside with round file, **clean wire terminal** with flat file—replace wire and draw connections tight.

Next examine the ground connection of battery to frame—this should be cleaned and tightened if not soldered. Looseness here is frequent cause of open circuit. Then examine connections from battery to starting motor switch, thence brushes to commutator.

Watch the Starting Motor Wire.



Fuses, which will melt on a dead short circuit and open the circuit, are usually provided on all parts of the electric system, except from the battery to starting motor. The current here is too great for a fuse. Therefore it is plain to see that if the insulated cable (I), should become frayed and touch the frame or any metal part of car, a **dead short circuit** would result—and if left shorted for several hours, the plates would likely become buckled inside of battery and touch each other and cause an internal short circuit which could not be repaired. A battery is on practically a dead short circuit each time engine is started, but only for a moment.

Care of the Generator.

Care of the generator is next in importance and should be given more frequent attention than the starting motor.

†Brushes.

Brush care—Once or twice a season the flat coiled springs holding the brushes against the commutator should be raised and the brushes examined, to see that they operate freely in their holders. Oil or dirt should be removed with a stiff bristle brush and gasoline.

Faults in brushes and brush holders can be classified into five divisons namely; grounded, poor spring tension, sticking in holder, poor fit to commutator surface and over-heating holders. When grounded, it is due to defective insulation or dust deposit.

When spring tension fails, the brushes are worn too short, the tension is not adjusted or has been thrown out, due to heat, or the springs themseleves may be broken. **When the brushes stick,** it may be due to binding or from dirt and grease. A little gasoline may tend to loosen same. When the brushes do not fit the brush holders it is a matter of manufacture. **Overheating of brush holders,** is caused by the sparking due to ill fitting brushes or no brush lead connection and lack of sufficient pressure on brush.

---

*See page 400, next to lower right paragraph. **See also pages 422, 454, 457, 458, 416, 410.

†**Brushes for generators are usually made of carbon,** because it is often necessary to have a brush with a high "contact drop," (meaning slight loss of voltage between brush and commutator because of contact resistance). See also, paragraph 5, page 404, about relation of the carbon brush and mica.

The starting motor brush is usually made of **wire** gauze, or composition, see page 405.

‡**Often times a battery will show 1.275 on a hydrometer test**—yet fail in current supply immediately after use; due to plates being sulphated. Test each cell with voltmeter and if test shows any of the cells below the others (see page 410), then test that cell with a "Cadmium Test" (see index)—as plates are likely sulphated.

Sparking at the brushes. If there is any sparking, or if the commutator becomes dull, you may be perfectly sure that either **the brush holder springs are too loose,** or **there is excessive vibration,** which may be due to a bent shaft, an unbalanced gear pinion, or defective mounting. Brushes should be kept in perfect contact with commutator, and it is advisable to use only the kind recommended by the manufacturer.

It may be found that where the generator is also used as a starting motor, sparking will in time develop at the commutator. This is due to the arcing of the heavy starting current at the trailing edges of the brushes, and the trouble may be eliminated by filing down their contact surfaces.

Carbon dust (providing carbon brushes are used) may be worn from brushes by commutator, and deposited in lower part of generator—**this ought to be blown out with air,** otherwise it might cause a ground.

**Commutator.

Commutator troubles can be divided into two heads. First, those due to defective manufacture and those due to surface wear or deterioration in service.

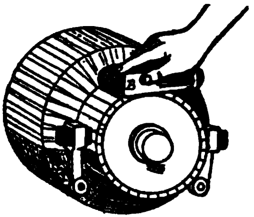


*Fig. 2.—The commutator is smoothed with a block of wood around which is wrapped a piece of sandpaper. (see also page 404.)

Sometimes this work may be done with the armature in place, but more often it must be removed.

Defective commutators may be grounded, have a short-circuit between their segments or have loose segments and are generally denoted by sparking at the brushes.

Those that have deteriorated in service show a rough or blackened surface due to the following causes: sparking from worn or short brushes, sparking on account of high mica, cheap brushes, oil collection on commutator surface, loose copper segments, poor contact between brushes and commutator, (generally due to sticking holders) or poor contact, due to weak brush spring pressure.

†**Commutators should be kept smooth.** If blackened or rough they can be dressed with fine sandpaper, while armature is rotating. (see fig. 5, page 404 and page 406.)

Never use emery cloth. After smoothing down examine and see if particles of metal bridge across the copper segments.

**High Mica.

Mica between commutator segments should not protrude, (see fig. 3, page 404); this can be dressed down on the lathe, per fig. 4, page 404, or in some instances filed down by using a very fine cut file, but care must be taken that no small particles of copper are left bridging across segments. A knife edge file can be used to cut between segments to get effect shown in upper illustration "after," fig. 4, page 404. This work must be done by removing armature and preferably on a lathe.

Commutator greasy—wipe with dry cloth, not waste, remove grease (chart 189).

Submerged Motor-Generator.

The generator must be kept free from excessive moisture. Ordinary moisture will not affect it, but should not be allowed to become thoroughly wet, such as would be the case if the generator were to become submerged under water. This is likely to happen while fording a stream. If the generator is wet it should not be operated until it is thoroughly dried out, this can be done by removing from car and baked 24 hours in an oven, whose temperature shall not exceed 220° Fahrenheit. A higher temperature in the baking oven would damage the insulation.

Generator Does Not Generate Full Output.

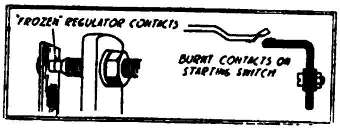
Symptoms; if meter shows 9 to 15 amperes (varies on different systems), at a speed of 18 or 20 m. p. h. then generator is probably giving its maximum output. If however, meter shows but 5 to 8 amperes at same speed then it is not giving its output.

Cause; (1)—if a third brush is provided (page 405), the adjustment may not be correct; (2)—ground in circuit; (3)—brushes grounded with brush holder and frame with carbon dust; (4)—brushes worn or not seating; (5) commutator dirty or out of round; (6)—high mica (see pages 404 and 409).

On many generators, as Autolite for instance as used on Chevrolet "490," page 364, there is no third brush or adjustment and failure of generator to generate full current is likely due to one of the above causes. See Overland "Autolite," page 358.

*Cut-Out or Relay.

Failure of the cutout to operate may be due to several things. In the first place a back kick will cause the points to close and stay closed and when ever this happens, no time should be lost in separating the points. This may be done by starting the engine again or by pulling them apart.


"FROZEN" REGULATOR CONTACTS
BURNT CONTACTS ON STARTING SWITCH

There are several mechanical reasons why the cutout may fail to operate. The points may be too near together or too far apart; they may be rough or pitted. If the former, they should be adjusted and if the latter, they should be smoothed with a fine file and then adjusted. The spring which holds the cutout open may be weak or broken or the armature on cut-out may stick, due to worn or tight parts or dirt. Be sure points are smooth.

The cut-out armature may be drawn to magnet core, yet points may not make contact.

Electrical defects in the operation of the cut-out are confined to bad connections or grounds. These troubles are rare and should be quickly evident after an inspection. Failure of the cutout armature to open when the engine is stopped would indicate trou-

---

*See pages 421 and 417. **See pages 404, 406. †Sometimes brushes wear down and brush holder cuts commutator. In this case, armature must be removed and trued up on a lathe—see fig. 4, page 404.

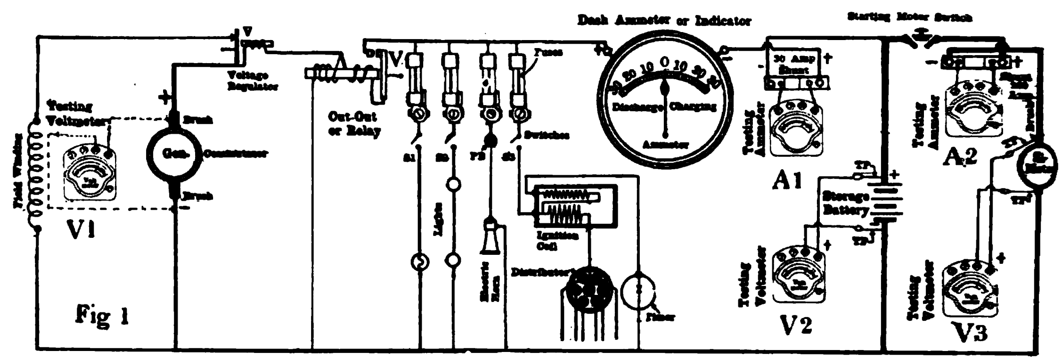


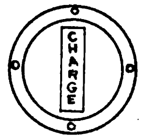
Fig 1

How the Volt and Ampere Meter are Used.

The idea of this combination electric system is to show where and how a volt-meter and ampere-meter can be used on the average electric system. It is understood that the battery is a 6 volt 3-cell battery and also that the only instrument which is a regular equipment is the "dash ammeter"—or which could be an "indicator." The other instruments V1, V2, V3, A1, A2, are testing instruments, as will be explained.

An Indicator.

Is now seldom used but will be found on some cars. It is placed on the dash. When generator is charging battery it shows "charge" as per illustration to the left. When battery is disconnected from generator at cut-out (V), it shows "discharge" if lights are on and engine running below speed where cut-out operates. If lights are off, ignition off and generator off, it will show "off."



The Dash Ammeter.

Is in general use and instead of showing the word "off," "charge" and "discharge," a scale is used per fig. 1 above, and fig. 8, page 415.

Note. On some of the dash ammeters the "charge" is on the left side, or reversed, for instance, see fig. 9, page 378.

Meaning of zero center: Note the "0" is in the center and when no current is flowing the needle will remain at 0 or zero. The needle can read up to 30 amperes on the "charge" side, to the right, or 30 ampers on the "discharge" side, to the left and is termed a "30-0-30" scale.

If generator is running sufficient speed to charge battery, then cut-out point V will close and connect generator with battery and charge battery, at which time needle will move to the right or "**charge**" side of 0—if connected correctly.

If engine slows down, and cut-out V opens, then battery is disconnected from generator, and as ignition is being consumed from battery the needle will move slightly on the left of 0, or "discharge" side of zero—as the battery would be discharging instead of taking a charge. If lights were on, then the needle would go further on the discharge side, as more current will be discharging from battery.

The above clearly shows that needle moves one direction when current is flowing from positive connection (+) of generator—to (+) of meter—to (+) of battery, but needle operates in **opposite** direction, when current is flowing **back from battery** to meter—as you will note connection is with negative side (—) of meter in this instance—hence **reason for zero (0) in** the center on the dash ammeter.

Voltmeter Tests.

The voltmeter is always placed across the line and shows the voltage or pressure of a circuit. The instrument used is the Weston, per page 414—which read carefully.

Test VI: To test voltage of generator: Use the 0 to 30 connections and scale. The **maximum** voltage will be indicated when generator is operating at 7 to 10 miles per hour car speed. The cut-out (V) should close and voltage going to **generator should be slightly over voltage of battery, in order** that it may force current into battery.

If voltage is lower, or no indication at all, **then** commutator may be dirty, brushes may not bear on generator commutator, or rough commutator, or grounded brushes, open circuit, or short-circuit or grounds in field or armature winding—see pages 406, 404, 409, 402, 403.

Test V2: To test voltage of battery when discharging, with lights only, on, use the 0 to 30 volt connections and scale. The voltage, if charged, for a 3 cell battery will be 6 to 6.3 volts or 2 to 2.1 per cell. If **discharged,** it will be 5.4 volts, or 1.7 volts per cell.

If tested when starter is on, a charged battery will drop to 5.4 or 1.7 volts per cell, but will regain its normal voltage after a short while. If it drops to 5 volts or less, or 1.6 volts per cell—it is discharged, or if fully charged and drops this low, then, plates are sulphated or an internal short-circuit. See also page 416 and index for "**cadmium** tests."

Test V3: To test voltage which reaches starting motor from battery, to see if considerable drop, test with engine idle but starter switch closed for an instant. If drop is considerable there may be poor connection at battery terminals or ground connection—if a grounded system.

Ammeter Tests.

Ampere tests are to ascertain the quantity of current flowing. A "shunt" must be used—see page 414. Connect the shunt in the circuit as shown at tests A1 and A2, being sure positive (+) wire of circuit is connected to (+) connection of meter, and the negative (—) wire of circuit to .1 binding post of meter—see page 414.

Test A1: To test accuracy of dash ammeter; use the 30 ampere shunt and connect as shown. Speed engine up and note if the reading is the **same on** the dash ammeter as on the testing **instrument**—see also page 398.

Test A1: To test cut-out: Use 0 to 30 **shunt and** scale. At a car speed of 7 to 10 miles **per hour,** cut-out (V) should close and **at 15 or 20 miles car** speed generator should be charging battery **at 10 to** 20 amperes—if lights are off—(**varies on different** systems). If it shows less than 10 amperes the "regulator" or "third-brush" should be **regulated** to bring the current up to at least 10 **amperes,** 15 amperes being the average.

Throttle engine slowly and note needle will **drop** back towards zero and note when it reaches **zero** if cut-out (V) opens and at what car **speed.** See page 417 for trouble indications told by **ammeter.**

Test A2: To test amperage required by starting motor: Use the 300 ampere shunt and connect as shown. Test with engine idle. It is assumed that battery shows 1,275 to 1,300 hydrometer test, and is supposed to be charged. **Average starting motor requires 130 to 150 amperes.** If it shows 220 to 225 or more amperes, engine is stiff, short-circuit in motor or brush holders—or may be the starter mechanism is out of order. See also pages 416, 406 and index for "cadmium tests."

CHART NO. 189A—How the Volt and Ammeter are connected to the Electric System of a car for Various Tests. How to Test the Accuracy of the Dash Ammeter or Indicator.

also pages 414, 416, 402, 406.

ble in the series coil, while failure to close might be caused by a defect in either series or shunt coil.

††**To determine whether the cutout is working properly** the car should be driven on high gear at speeds varying from 6 to 15 miles per hour and the speed at which the cutout operates should be noted. The correct speed can usually be found from the makers instruction book.

Circuits.

See that all circuits between dynamo and battery are intact and all binding posts and contacts tight and remember that a complete circuit is necessary in order that the electric current may do its work.

*Adjusting Silent Chain.

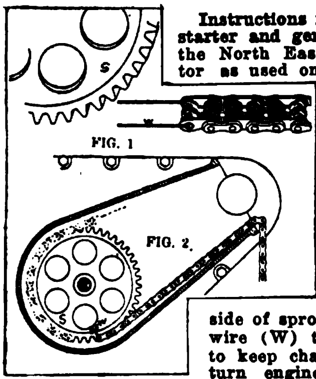


FIG. 1

FIG. 2

Instructions for replacing the starter and generator chain on the North East starter-generator as used on the Dodge car is shown in figs. 1 and 2 as an example.

First:—Pass short piece of wire through end of chain and bend into form of staple.

Second:—Start chain on lower side of sprocket (S). Hook wire (W) through sprocket to keep chain in mesh and turn engine with starting crank unit until end of chain appears at top of sprocket. Remove wire from sprocket, hold end of chain and continue to turn engine until chain is in position for applying master link.

Chain driven starting motors and generators should have the chain kept lubricated and adjusted, but never adjust chain too tight.

The silent chain which drives the generator should have frequent and thorough lubrication. Ordinary lubricating oil will do for this purpose and as soon as the oil has penetrated to all the joints the outside of the chain should be wiped clean so that a minimum of dust will adhere.

The chain may be tightened by loosening the two screws which hold the generator on its bracket and moving the generator over the required distance by means of the adjusting screw on the side next the engine.

Locating Generator Troubles.

Under the heading of "care of the generator" the subject of commutators and brushes was treated. This is usually the first place to look for generator troubles. Other troubles are:

Armature Troubles.

Armature windings may be burned out or grounded. When burnt out the trouble may be due to a current overload, due to improper regulation, a soaked winding or a steady and prolonged return flow from the battery, due to failure of the circuit breaker contact points to open. A grounded armature winding is due to defective insulation.

**Locating Armature Troubles.

Armature troubles are sometimes found in the attaching leads at the commutator segments. The solder attaching same, may be thrown off in revolving. This can be soldered back to the segment by an electrician.

Dim lamps, low voltage and undercharged battery might be the result of armature trouble. One of the armature coils might be short-circuited, burned out or a connection might be loose or broken.

Any defect in the armature will be indicated by an uneven torque. In the case of the generator this may be very easily tested by disconnecting the driving mechanism, holding the cutout points closed and allowing the generator to operate as a motor.

If everything is all right the armature will rotate evenly and in the same direction as when it operates as a generator. Whether the torque is even or not may be determined by holding the end of the armature shaft in the hand, and noting whether the pull is steady. An uneven pull means that one or more of the coils is not working; it is just like an engine with a missing cylinder.

If an armature coil is burned out or there is a broken connection the armature will invariably stop at a certain point; if this is the case, the commutator segments between the two ends of the coil will also be burned. Sometimes the broken connection occurs at the junction between commutator bar and the coil in which case the remedy is to resolder. All other armature defects should be left for the factory to remedy.

Another way to test for defective armature coils is to disconnect the field and then connect the ends of the lamp test wires to the brush holders. If the armature is perfect the lamp should stay lighted during a full rotation of the armature, but if there is a broken connection or defective coil it will go out when this is reached.

No current in the generator may be due to a broken connection, short circuit or broken driving mechanism. The last trouble should be looked for first, and simply means that the generator driving shaft should be tested to determine whether it is solidly connected to the engine or not. It is possible that one of the driving keys has sheared off or that the driving gear, chain or belt, as the case may be, has failed. (see page 402.)

---

*See pages 113, 729 and index "silent chains." †See instruction 32A, for storage battery troubles.

**See pages 402, 406, 416.

††**Ward-Leonard Co. state that the only way the cut-out manufactured by them could give trouble,** would be due to an open circuit in armature of generator, or open lead wire between battery and generator, or else the connections at battery be reversed. (see pages 342, 344 for Ward-Leonard.)

A broken connection at one of the brushes would prevent delivery of current by the generator. Likewise a **dead short circuit in the generator** would cause the same trouble.

Armature tests for ground, etc. are treated further on—see pages 402, 403, 406, 410.

. **A grounded generator** can be caused by an accumulation of dust worn from the brushes or a defective insulation of the armature or field coils.

Weak field magnets will vary in cause, according to whether the magnets are permanent or wound. In the permanent magnets the cause is generally due to exhaustion through long use, no keeper used when removing them or magnets reversed when reassembled. In wound magnets, shunt field coil or coils may be grounded, due to a water soaked generator or short-circuited through burning out, by running the generator with the battery disconnected. They may also be oil-soaked.

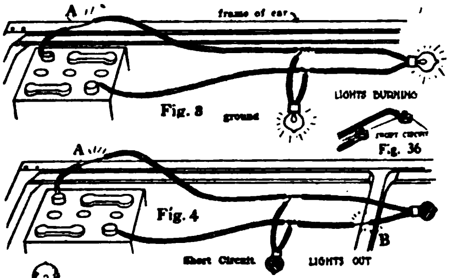
In the circuit-breaker or main contact, as it is often called, there may be a direct mechanical break, a burned out coil due to current overload or a ground due to defective insulation, a bad adjustment which does not allow the generator to cut in at all or if so at an improper speed or the contact points may be sticking. The latter is due to a mechanical break, disintegration of weights where worn out or dirty contact points, reversed wires at the generator terminal or a backfire of the engine.

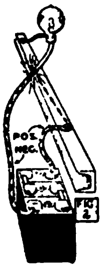
A short circuit in the circuit-breaker allows current to discharge battery through generator at less than charging speeds.

*Short-Circuits and Grounds.

A short-circuit means that two conductors of current are in metallic contact when they should not be.

For example, on a two-wire system as per fig. 4, if one wire was "grounded" to frame of car at A and B, a short-circuit would be the result—as the path of the current would be shorted.





On a single-wire system per fig. 2, we would have the same result; the frame of the car acting as the return wire.

On a two-wire system, fig. 3, if wire was "grounded" at A, the current could still flow to the lamp—therefore this would be termed a ground.

Therefore, the term short-circuit means that the wire is in metallic contact with its return circuit, which could be another wire, or the frame of the car or any metal part of car, if the latter is in metallic contact with frame.

A **"dead short-circuit"** is a term often used and applies to a short-circuit of such magnitude that the entire current carried is fully short-circuited by making firm contact. For instance, refer to fig. 4, in this instance a dead short circuit exists at A and B—therefore the battery would be shorted and result would be that wire would probably melt and lights would not burn at all. Therefore a fuse, if placed in circuit would protect the wiring and battery.

A slight short-circuit is where the wires are not making full contact but enough to make slight contact. For instance two wires close to engine, not properly insulated may make a slight contact due to heat, through insulation and dim the lights, or frayed ends of wires at switch terminals may bridge across and short the connection from jolting of car and occasionally cause the lights to dim or go out. Oil soaked wires may be close together and also cause a slight short circuit and result in dim lights and gradually weaken battery.

A ground means that the conductor or wire is in contact with metal part of car, as frame, engine, etc. It can be a bad ground where contact is firmly made or slight, where oil soaked or a damp wire, or poorly insulated wire is in contact with metal part of car, but not firmly as resistance of insulation prevents, but enough to cause **leakage** of current which will gradually discharge battery, and in some cases may become entirely discharged in a very short while.

This kind of a short circuit is first noticed when the starter seems weak and the lights seem to grow dim at low car speed, and brighten up as the dynamo cuts in.

Fuses.

Purpose is to protect the circuit against short-circuits which would heat the wire and discharge battery. Instead of the wire heating and melting, the fuse would melt.

Fuse wires are made in different diameters. It is made of lead alloy and will melt at a given temperature. If a lighting circuit required 10 amperes of current, then a 15 ampere fuse would be placed in the circuit. Therefore current up to 15 amperes could pass safely, but if more, which would naturally be the result if a short-circuit existed, the fuse would melt and open the circuit, (see page 428.)

See pages 441 and 207 for meaning of amperes, etc. (Illustration from Motor Age, by B. M. Ikert.)

*See also pages 406, 418, 403, 416.

Indications of Grounds and Short Circuits.

(1) Battery will become exhausted, regardless of the charging it receives. (2) Battery will run down (discharge) over night. (3) Lamps when turned on will burn dimly. (4) Ammeter pointer may go to limit of "discharge" scale. (5) Starting motor may act sluggishly, or not at all. (6) Fuses 'blow" repeatedly.

A short circuit in any lamp circuit will usually cause a fuse to "blow" or melt. If this occurs, it is evident that the wire leading from the fuse is in contact with the "ground" or frame of car, or other metal, or that insulation has been injured and conductor is in contact with ether metal, thereby grounding it to frame. The wire must be inspected along its entire length until trouble has been located and corrected.

Wire having injured insulation should be wrapped with friction tape to prevent contact with frame or other conductive material.

Some Causes of Grounds and Short Circuit.

First of all, the ground may be in the battery itself, and may be caused by buckled plates or an accumulation of sediment. The former trouble is usually the result of charging or discharging the battery at too high a rate, and the latter is due to neglect to clean the sediment out before the chamber provided for its collection becomes filled. This would be termed an "**internal**" **short-circuit.**

The next place to look for the "ground" in on the battery exterior. Spilled acid may cause a partial short circuit. The top of the battery should be wiped clean, treated with a solution of potash and then the metal parts should be covered with vaseline.

If current is flowing into the external circuit, this fact may be determined by disconnecting one of the battery wires and then touching it for an instant to the terminal it was just removed from. If any current is flowing a spark will be seen. If any considerable amount of electrical energy is being lost, this fact should also be indicated on the ammeter if one is fitted.

The most likely place to look for trouble is in the cutout, as it may be closed. The failure of the cutout to open may be due to several things, taken up under the heading "Cutout or Relay."

As a precaution the starting switch should be examined, as it is possible that it did not release fully the last time it was used and that some current is short-circuited through it.

Having gone through these preliminaries, the next step is to start from the battery and examine all the circuits, taking the main ones first. Disconnect the main feed wires where they enter the junction box or battery, and note whether the ammeter goes back to zero. If it does there is a ground between this point and the battery.

Put these wires back and then disconnect all other wires from the junction box. If current is still flowing the trouble is in the junction box, but if not it must be in one of the circuits running from this point. If this is so, then remove wires and test each separately.

*Testing for Grounds and Short Circuits.

First be sure a ground or short circuit exists. This test can be made several ways. **The amperemeter will indicate same by showing "discharge," but if there is no amperemeter on the car, then open all switches, disconnect one terminal of battery (usually a lead lug), strike the connection lightly against battery terminal in quick succession. If a spark occurs, even though very slight, it indicates a "ground" or "short circuit" (see page 406, 403, 418).

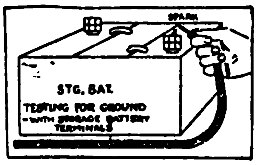


Fig. 6. Testing for grounds.

The next procedure is to find the ground or short circuit.

(1) Examine first, the battery wiring. Examine carefully all of the conductor wires connected at one end of the battery terminals and at the other end to the bus bars of the lighting switch. Make certain that the insulation is perfect, and that no sharp metal corners or edges cut through. Also that no frayed wires are bridging across at the bus bar. In the same manner examine carefully the wiring from the battery to the starting motor and starting switch. If battery has been discharged, have it recharged. See also page 241.

(2) Examine lamp base and socket, quite often the slight short circuits are located at this point. One of the strands of wire where attached to small screw in lamp socket may be touching—examine lamp base. If not at this point the trouble may be found in the wiring where connected to lamps having worn. Electric light bulbs, if loose where the glass part is cemented to the metal base, will also cause a short circuit, as the "lead-in wires" are very close together, and jolting of the car will cause these leads to touch one another, this means a new bulb and perhaps a new fuse. Defective lamps should be discarded, before they cause trouble, see also page 403.

---

*Also pages 402, 403, 406, 418, 416.

**This instrument is usually referred to as an Ammeter—see pages 410, 414.

A Combination Volt-Ammeter for Automobile Electric Tests.

Instead of having a separate voltmeter and ammeter. it is possible to combine both in one instrument, using the same scale. The **Weston** model 280, garage testing voltammeter will be used as an example.

As a Voltmeter.

When using instrument for volts: See fig. 1, and note terminals are marked .1, 3, 30, +. The positive or (+) terminal of instrument is **always** connected with the positive (+) wire of circuit being tested. When making connections where polarity is not known, the needle will deflect to the left if connected wrong—reverse connections.

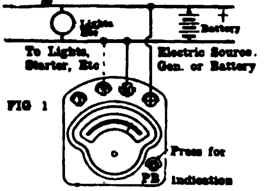


FIG 1

If voltage to be tested is known to be between 3 and 30 volts, then connect the other or negative (—) wire to terminal marked 30 and use the scale 0 to 30, the divisions of scale being 0.5 volt for each line (the scale fig. 4, has 60 divisions).

If voltage is known to be between 1 to 3 volts, connect negative wire with terminals marked 3, and use scale 0 to 3, the divisions of scale being 0.05 volt for each line.

If voltage is known to be less than 1 volt, connect negative wire with terminal marked .1, and use scale 0 to 3.

When making voltage or ampere tests, the button (PB) fig. 1, is pressed for indication.

The zero adjustment, fig. 2, is merely used to line up needle with zero or "O," when starting to use instrument.

A voltmeter is always connected across the line, as per figs. 1, V1 and V2, page 410. It is used to indicate the voltage **pressure** of an electric circuit.

As an Ammeter.

When using the instrument for measuring amperes, it is connected in **series** with the circuit and is intended to indicate the quantity of current flowing.

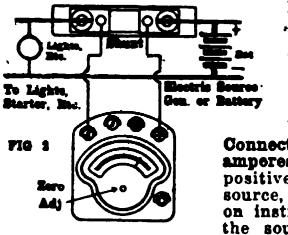


FIG 2

It is important to note that a "shunt" must be used per fig. 2. The purpose of which is explained further on. A shunt is not used with the voltage tests.

Connections for measuring amperes: Always connect positive (+) wire of source, with (+) terminal on instrument. Note fig. 2, the source of electric current is the positive terminal of storage battery. Current then flows to shunt connection, thence to (+) terminal of instrument, through instrument, out the .1 terminal on instrument, to other connection on shunt, thence to one side of light or starting motor, etc., through lamp or starter, back to negative (—) side of battery. See also page 410. Only the (+) terminal and .1 terminal are used when instrument is being used as an ammeter.

Shunts.

A shunt is merely a choker or a form of resistance metal R, fig. 2A, which is "shunted" between the two terminals (+ and .1) of meter per fig. 2. It must be used with all ampere tests.

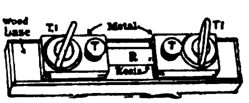


Fig. 2A.

The reason a shunt must be used is due to the fact that it is not practical to carry more than a fraction of an ampere through the moving coil K, fig. 4, of the meter. Where currents are small, the shunts are usually contained in the meter case, but for large current, external shunts are used so as to keep the heat developed in the shunts outside the meter and also for convenience, as the shunt can be located in the circuit wherever easiest and connected with meter by a small cable, thus saving running heavy wires to the instrument.

As stated only a fraction of an ampere can pass through the meter, therefore, in order **that** 1/10, 1/100, 1/1000 part of the total current **shall pass** through the meter, it is necessary that **the resistance** (R) of the shunt be such that 9/10, or **99/100** or 999/1000 part of the total current will **pass through** the shunt—which is all figured out by **the manufacturers** and it is only necessary **to know** the capacity of the shunt and connect as **shown in fig.** 2 and then take the actual readings on **the scale**.

A millivolt is 1/1000 part of a volt. **The connection** .1 on meter is often referred **to as the 100** millivolt terminal, which is 1/10 of a **volt.** This however, refers to the millivolt drop in **the shunt** which is figured out by the manufacturer **and** is of no interest with automobile work.

Capacity of Shunt to Use and Range of Scale.

Shunts to use with this instrument: There are three external shunts as follows:

300 ampere with which use the scale 0 **to 300.** Each division or mark on scale represents 5 amperes.

30 **ampere,** with which use the scale 0 to 30. Each division or mark represents 0.5 amperes.

3 **ampere,** with which use the scale 0 to 3. Each division or mark represents 0.05 amperes.

When testing where you do not know what the amperage is likely to be, as testing for short circuits it is advisable to assume that the highest **possible** amperage is to pass through meter, **therefore** use the 300 ampere shunt. If the deflection obtained is less than 30 amperes, then use the 30 ampere shunt and scale, to gain a more accurate reading. Should the indication now be less than 3 amperes, use the 3 ampere shunt.

The 3 ampere shunt and range is convenient for measuring single lights, and ignition.

The 30 ampere shunt and range is convenient to measure current delivered by generator to battery per A1, fig. 1, page 410; for measuring current required by the lights, horn, etc., and also for testing short-circuits and open circuits per page 402, 416.

The 300 ampere shunt and range is convenient for measuring the current required by starting motor, per A2, fig. 1, page 410 also for testing for shorts.

Internal Connections

Of the Weston model 280 garage testing voltammeter is shown in fig. 4. Note when button PB is pressed the current flows through the moving coil, then through resistors. Resistance C is the adjusting resistor for the 100 millivolt range: C and B are in series for the 3 volt range and C, B and A in series for the 30 volt range. When used as an ammeter, the + and 100 millivolt, or .1 binding posts, are connected to the terminals T on the shunt fig. 2A. The main current passes through the external shunt. When button PB is pressed only sufficient current passes through the instrument to cause it to properly indicate.

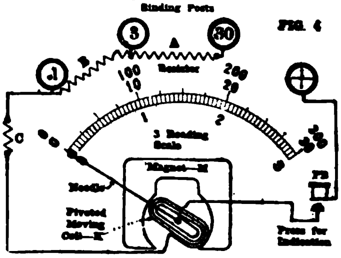


FIG. 4

Ammeter Principle.

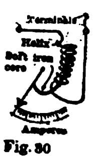


Fig. 30

The original "gravity" principle of an ammeter, which is now seldom used, is shown in fig. 30. Note the "helix" draws the iron core into it, thus moving the needle. Greater the current, greater the draw. **The modern principle is the "moving coil, permanent magnet" type,** per fig. 4.

CHART NO. 190—Description of the Volt-Ammeter. See also pages 416, 410, 402, 403, 406.

Note—A. L. Dyke, Electric Dept., Granite Bldg., St. Louis, Mo., is in position to supply electrical testing instruments. See advertisement in back of book.

(3) Test each lamp circuit separate. With engine at a standstill, close the several switches to the lighting circuits one at a time and watch the ammeter needle closely as each switch is closed. If the needle swings to the "discharge" side of the instrument and holds there, a short circuit exists somewhere in the circuit whose switch is closed. Try all circuits in this manner, one at a time. If the ammeter indicates only the proper amount of current consumption for the several lighting circuits, as they are switched on, no further search for short circuits or grounds is necessary. However, if the ammeter needle swings against the side of the case as above, for one or more circuits, then you must proceed until the trouble is located—see pages 406, 418, 403.

If there is no ampere-meter on the dash to guide you, then it will be necessary to continue search until there is no spark at the battery terminal with switch open. If the trouble is found in poor insulation, then wrap the part with friction tape.

Testing wires for short circuits, also see pages 403, 406, 418, 410.

*Open Circuits; Meaning of, and Indication.

An open circuit is an incomplete circuit. Therefore, it does not offer a passage for current.

Ammeter does not indicate either "charge" or "discharge." Lamps do not light when turned on.

Starting motor does not crank engine when starting pedal is pressed to the full limit of its travel.

Open circuits, may frequently be located by examinations of all wires and terminals. Loose screws and nuts, poorly soldered and insecure wires, corroded connections and terminals are likely to be the cause of open circuit. Go over the wiring carefully before making tests.

Wire and terminals should make good contact. The parts making contact should be clean. Solder all wire connections and use common baking soda and water for cleaning battery terminals.

If ammeter does not indicate "charge" when engine is speeded up, or does not indicate "discharge" with lamps turned on, engine at rest, an open circuit exists between dynamo and battery.

If any one lamp fails to light, it indicates open circuit in that line. "blown" fuses, broken lamp filament, or broken lamp wire may be responsible.

If all lamps fail to light when engine and dynamo are speeded up, the open circuit is most likely located between battery and dynamo, or between dynamo and lighting switch.

The "blowing" or melting of a fuse opens the circuit and disconnects from system the short-circuited wire which caused fuse to blow.

In testing for open circuits the first thing to determine is, which one of the circuits is open; then see if connections are o. k. If so, then test the suspected wire and see if it is broken inside of its insulation by running another wire temporarily in its place and note if it remedies the trouble.

An open circuit that happens often, and one that is difficult to find, is a broken wire inside of the insulation of the lighting wiring. The easiest way to find the break, is to connect both ends of the suspected wire to a dry cell and a bell, in such manner that the bell would ring if the wire isn't broken. Then take piece of thin wire about 3 feet long and wrap each end of it around two ordinary pins with one pin in each hand, stick them through the insulation, when bell rings, the break is somewhere between the pins.

Testing current flow: Whether or not current is flowing in a given circuit may be determined by removing one of the wires forming the circuit, and then touching it to its terminal. If a spark occurs current is passing through the line—also see page 418, 403, 410, 406.

**The Ampere Meter (also Ammeter).

†Purpose: It is provided as a signal for the operator. In case current is not being generated, due to loose connections, broken wire or other causes, the operator is informed of this failure in time to have the trouble remedied before the battery is exhausted.

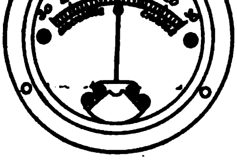


Fig. 8.

(1) It indicates when the dynamo charges battery, and at what rate. (2) It also indicates the rate of discharge from battery to lamps. It shows whether or not the system is working properly. **(3) When battery is neither charging nor discharging,** the pointer should indicate "O."

The ammeter is placed in series with the circuit, as shown on page 391, 410. It shows the amount or quantity of current, the lights, ignition, and horn use, and the amount of current the generator puts into the storage battery.

It does not show the amount of current used by the starting motor, and should not be used thus, unless special shunt resistance is used in connection as explained on page 410, and 414, 416.

The ammeter needle indicates that battery is being charged by generator when the needle is on the right side of (O.) The amount of charge in amperes is indicated on the dial by figures, fig. 8—see also page 410.

---

*See pages 416 and 418. †See page 414 for principle of operation.

**See page 398, 414 for construction of a volt-ammeter. Also note that on ammeter, fig. 8, the discharge is on the left side. On page 378 (Delco-Buick ammeter) the discharge is on the right side. This varies with different makes.

Electrical Troubles: Indications, Causes and Volt-Ammeter Tests for Same.

The electric system of a car consists principally of four units, per page 410 and as follows:

(a) generator, including the regulator and cut-out.
(b) battery.
(c) starting motor, including starter switch.
(d) wiring system.

(a) Generator Troubles.

Generator troubles are:

(1) failure to generate current at all.
(2) failure to generate sufficient current.

Indication of (1) is: failure of dash ammeter to show charge. **Cause;** fuse blown; open circuit; short-circuits and grounds in the field or armature circuit of generator. **Tests;** see pages 410, 406, 402, 403.

Indication of (2) is: low reading on dash ammeter. **Cause;** brushes not set for proper current; regulator defective; dirty commutator, brushes not bearing on commutator; commutator worn; brushes grounded. **Tests:** see pages 406, 404, 410, 402, 403.

(b) Battery Troubles.

Battery troubles are:

(1) failure of generator to charge battery.
(2) battery will not hold charge.
(3) battery voltage drops immediately after charging.

Indication of (1) is: ammeter does not show charge. **Cause:** may be due to generator, see "generator troubles;" may be due to cut-out not operating properly; may be due to open-circuit in the line. **Tests:** see pages 410, 406, 402, 403.

Indications of (2) are: slow cranking of starting motor, dim lights when battery supplies current; missing of ignition. **Cause:** may not be getting sufficient charge from generator; may be running mostly at night with lights on; excessive current consumption of starting motor; internal short-circuit of battery cells; grounded wiring system. **Tests;** see pages 410, 422, 403, 406.

Indication of (3) is: starting motor turns over very slowly and lights dim considerably. **Cause:** internal short circuit of one or more cells; grounded starting motor switch. **Tests:** see page 410 for battery test, then see index for "Cadmium test" of battery cells. See also, pages 422, 458, 461, 408, 456.

(c) Starting Motor Troubles.

Starting motor troubles are:

(1) failure to operate.
(2) operates slowly and not sufficient power to crank engine.

Causes of (1): Battery weak, test per figs. 2 and 1; open or short circuits or grounds may exist in wiring from battery to starter switch (see page 408); sticking starting switch (common); mechanical trouble with starter mechanism. **Test** by examining each carefully. If none of these causes, then the trouble is an internal one of motor and may be due to open circuit in motor armature or field. **Test** per pages 402, 403, 406. Or may be due to dirty commutator; grounded brushes. **Test** per pages 406, 404, 409.

Causes of (2) are: battery discharged—**test** battery; poor contact at battery terminal or ground wire from battery to frame; poor brush contact; dirty commutator. **Test** per pages 406, 410.

(d) Wiring System Troubles.

Wiring troubles are:

(1) all lights out, none burn.
(2) only one branch of lights burn.

Cause of (1): Fuses blown; battery discharged or disconnected; poor connection at battery terminal or ground wire; open-circuit; short-circuit. **Test** battery; examine connections—see page 406, 418, 403, 419.

Causes of (2): open-circuit; short-circuit or ground in this branch. **Test** per page 403, 406, 418. May be due to burned out lamp bulbs or poor contact at lamp sockets. See pages 419, 420, 424.

Miscellaneous Tests.

On page 414 a voltmeter is described which is used extensively by repairmen for electric tests as follows:

Horn test, page 418.
Cut-out and dash-ammeter, 410.
Fuses, 428, 418.
Generator and starting motor, 424.
Grounded armature coil, 402, 406, 410.
Short-circuited armature coil, 402, 406.
Grounded field coil, 403, 406.
Short-circuited field coil, 403, 406.
Commutator troubles, 404, 406.
Wiring system, grounded and shorted, 403, 406, 418.
Starting motor shorted, 406, 410.
Battery tests, 410, 406, 450, see also index for "cadmium tests."

Battery Tests.

A battery is usually tested with a hydrometer, but sometimes it tests 1275 to 1300 which is supposed to be charged, yet fails to hold its charge. In this instance, use 30 volt connection on meter per figs. 2 and 1, page 410. Note what it should show in volts on page *410*.

FIG. 2

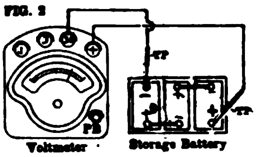
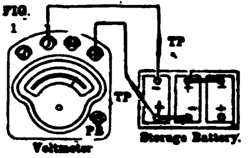


FIG. 1



If all cells do not come up to test, then test each cell of battery separately when in order to find on normal discharge, which cell is defective, per fig. 2. See page 410, showing what it should test, see also index for "cadmium test." Each cell should show the same

To test current consumed by starting motor, see page 410.

·Field Coil Tests.

Note illustrations figs. 3 and 4 and observe the difference between a "ground" and a "short-circuit."

FIG. 3

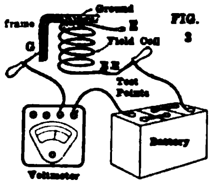
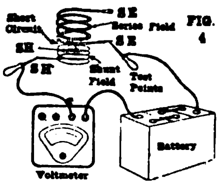


FIG. 4



When testing field for a ground, be sure both field coil ends, E and EE are disconnected from all terminals. Use 30 volt connection as shown in fig. 3. Place one test-point on EE and other on frame at G, if deflection is shown, the coil is grounded and a new one must be supplied.

To test if open circuit, place one test-point on E and other on EE, if the voltage is the same as if the two test-points were placed together, then coil is o.k. If needle of meter does not move, coil is open.

On generators, there are usually two windings, a series and a shunt, fig. 4. Disconnect both ends of both coils (SE, SH), and be sure the ends are not in contact with frame or metal parts. Use 30 volt connections on meter. Place one test point on one end of series (SE), other on shunt coil end (SH); if short-circuited, there will be a deflection of needle. If not shorted, there will be no deflection of needle. See also pages 403, 402.

CHART NO. 191—Electrical Troubles and How To Test with Voltammeter—using meter explained on page 414. See also pages 402, 406, 410.

Ammeter Indications.

When generator is not charging battery, and if battery is being used for lights, ignition, or horn, the needle will be on the left side of (O) and amount of current being consumed, will be shown in figures on dial. (see fig. 8, page 415, 410.)

If on connecting a meter the needle should go to the left, or discharge side, when engine is running at fairly good speed and generator was generating current, then it indicates that the terminals have been connected wrong — reverse the connections. (needle may also be bent).

If needle is forced to the scale limit on discharge side, it indicates an overload or short circuit.

When engine is running and lamps burning and ammeter hand stands at zero, it indicates the generator is producing exactly the same amount of current that the lamps are consuming.

When car is running 12 miles or more per hour, with lights off, ammeter should indicate "charge."

Average Ammeter Readings.

The following scale will give an average reading of an ammeter with lights off and on:

Car Speed	Lights	Am. Readings.
At rest	Off	Zero
At rest	On	Discharge 5-7 amp.
Below 6 or 8 m.p.h.	On	Discharge 5-7 amp.
Below 6 or 8 m.p.h.	Off	Zero
Above 10-12 m.p.h.	Off	Charge 5 to 9 amp.
Above 10-12 m.p.h.	On	Charge ½ to 3 amp.

These readings are based on lamp equipment of two 16 c. p. 7-volt headlights, and one 2 c. p. rear lamp.

*Trouble Indications as Told by the Ammeter.

In this instance we refer to the ammeter as usually attached to the dash board of a car (pages 415, 410, 406.)

Ammeter troubles may be divided into two classes: those that manifest themselves when the engine is idle and those that only show when it is running. Both classes have two subdivisions, with lamps on and with lamps off.

Remember that the ammeter should show "charge" at speeds above 8 or 10 miles per hour; and that when engine is at rest and lights turned off, needle should stand at "zero" and not show "discharge." It shows "discharge" when lights are on and engine idle or speed less than 8 miles. In other words battery is then discharging—see page 415.

If ammeter shows "charge" instead of "discharge," and shows "discharge" instead of "charge," it indicates that the wires connected to the rear of ammeter should be reversed.

†**Ammeter shows "charge" at slow speeds and "discharge" at high speeds—or in other words opposite to what it should show;** this indicates that battery terminals are reversed, because at low speeds battery is supplying current for ignition and should show a slight "discharge," but as an ammeter hand operates opposite to what it should, when connected wrong, it would show a slight "charge."

When at nine miles speed or more, the generator should cut-in and charge battery and ammeter should show "charge," but as terminals are reversed it would show "discharge."

If ammeter indicates zero when the dynamo should be charging battery, it shows that the circuit is open, or dynamo is at fault.

Ammeter does not indicate "charge" when engine speeds up—but indicates "discharge" when lights are turned on, engine at rest.—Dynamo or regulator not working properly. Dynamo brushes do not slide freely in holders.

Ammeter does not indicate "charge" engine speeded up—and does not indicate "discharge" lights on, engine at rest.—Open or loose connection in the battery circuit. Battery terminals loose. Dynamo terminals loose. Ammeter may be at fault.

Ammeter indicates "discharge" lights turned off, engine at rest.—Ammeter pointer bent. Insulation on wires injured, permitting contact with frame, causing ground or short circuit. Cut-out points stuck.

If the trouble seems to be in the ammeter, it is well to place a **test** ammeter in circuit, to check the first instrument. If the instrument registers incorrectly it should be returned to its makers for repair.

Ammeter indicates "charge," engine at rest.—Ammeter pointer bent. If current is flowing, meter or battery **terminals** connected wrong.

****Ammeter "charge" indications below normal.**—Dynamo output varies with condition of battery. (see also page 409.)

Ammeter "discharge" indications above normal.—Lamp load excessive or old lamps. Wires grounded or shorted.

Ammeter pointer jerks intermittently to "discharge," limit of scale while engine is speeding up.—Short circuit in system.

Fuses blow out repeatedly.—Heavy ground or short circuit or the fuse may be too small for the current required.

If larger than standard bulbs or extra lamps are used "discharge" indications will be higher. The generator may not be capable of charging battery sufficiently to overcome the excess load, especially if there is insufficient day driving or excessive use of lamps at night, thereby permitting battery to discharge more rapidly.

---

†Varies on different systems. On some systems the cut-out will vibrate rapidly and meter needle swing back and forth—see also page 421.

*This applies as well to the indicator, which is in reality an ammeter. The instructions may vary for different systems. **For testing storage battery with a volt-meter, see chart 191, and also index.

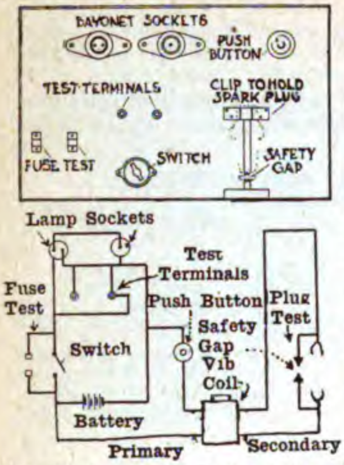


Fig. 3—A test board for bulbs, fuses, spark plugs and horns.

Electric Testing Board for Lamps, Spark Plugs, Horns, Etc.

Illustration fig. 3, shows a test board and wiring for same, for testing the following:

1—Lamp bulbs; either single or double contact bases, see page 432.
2—Fuses—see page 428.
3—Spark plugs.
4—Horns.

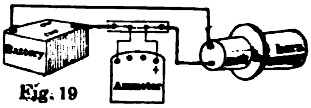


Fig. 19

Quite often a lamp does not burn. It may be due to the lamp being burned out, or an open-circuit in the wiring. To first determine if it is due to the lamp bulb, it can be quickly tested. If it is o. k. then the trouble is in the wiring. This also applies to the fuse.

The horn can be tested by placing an ammeter with the 30 ampere shunt (see page 414) in the circuit, per fig. 19. Then adjust to take the least possible current. The average horn draws from 3 to 8 amperes, owing to its size—see page 514. The ammeter can also be used to test the horn for short-circuit or open circuit.

Electrical Testing Outfits.

Testing outfits for the electrical repairman which can be added are:

5—Magneto tests per pages 301 to 304.
6—Magneto remagnetizer, pages 301, 303.
7—Cadmium test for storage battery, see index.
8—Hydrometer outfit, per page 452.
9—Storage battery portable testing outfit, page 474.
10—Portable lamp and plug testing outfit, page 710.
11—Battery bench, per page 474.
12—A steamer for batteries, per page 473.

Other outfits for the electrical testing and repair department could be added as follows:

13—A cleaning outfit for parts, page 401.
14—Test points and meters for generator and starting motor tests, per pages 402, 403, 414, 474, 424, 410.

How to Locate an Open Circuit with the Test Point and Lamp.

"Test-points" used in connection with a 6-volt "test-lamp" can easily be constructed by following the illustration in fig. 1. For emergency use any two lengths of wire with bared ends usually will serve.

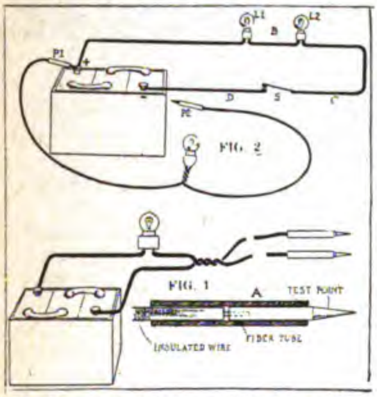


Fig. 1: A test lamp and battery, for locating troubles in the electric system.
Fig. 2: Test lamp for locating troubles in a series lighting circuit.

Should test lamp fail to light under any of the following conditions, it is an indication that there is an open circuit between the last point where the test lamp would light, and the first point along the circuit where it failed to light. Suppose you had an open-circuit in your lighting wiring system—proceed as follows:

1—Be sure the **fuse** is not open, by testing it, per page 428.
2—**Test battery** by placing one test point, P1, fig. 2, to positive terminal of battery, the other test point, P2, to the negative terminal; if the test lamp lights, then you know the battery is o. k.
3—**Test the wire to switch,** by placing test point, P2, at D; if test lamp lights, then you know your wire to this point is o. k.
4—Move test point P2, to C, on the other side of switch, close switch; if test lamp lights, then you know **the switch** connections are o. k.
5—**Test the lamp L2,** by placing test point to the right-hand terminal of lamp L2; if test lamp burns the wire C is o. k.
6—Move P2, to the left-hand terminal of lamp L2. When this connection is made the test lamp and lamp L2 will be connected in series across terminals of battery. If lamp L2 is o. k. the filament of test lamp will brighten up, but not to the same extent it did when connected to the right-hand terminal of L2.
7—Move P2 to right-hand of terminal of lamp L1; if test lamp glows the same as when the test point P2 was connected to left-hand terminal of lamp L2, then wire B is o. k.
8—**To test lamp L1 and wire leading from (+) terminal of battery to lamp L1, may be tested** by placing test point P2 on the negative (—) terminal of the battery, and the test point P1 on the left-hand terminal of the lamp L1; if test lamp lights, this lead is o. k.
Then move test point P1, to right-hand side of L1, which places the test lamp and lamp L1 in series; if lamp L1 is o. k. the test lamp will light, but not at full voltage, due to resistance of lamp L1 in series with it.

Testing For Short Circuits with Test Point and Lamp.

Short circuits between two wires may be tested for, with the test lamp and battery shown in fig. 1, by placing one test point in contact with one of the wires, and the other test point in contact with the other wire. If the test lamp lights it is an indication that the two wires being tested are connected or short-circuited—see also page 403.

CHART NO. 192—Electrical Repairman's Testing **Outfits. Test Points and Test Lights**—see also pages 403, 402, 406, 410, 424 and 414.

Ammeter shows excessive "discharge" at low speeds or engine idle; this is caused by the cut-out contacts being held closed or "stuck," and means a dead short circuit of the battery through the generator. This must be corrected at once by disconnecting the points, see pages 409, 411, 410.

The ammeter will always indicate if a short circuit exists in any part of the wiring, **except** from the battery to the switch bus bar, and in the **starting motor circuit.**

Ammeter Troubles.

Tapping the ammeter should jar the hand loose if it is only stuck. If it still refuses to register examine the connections, and if these are all right look at the cutout. Finally disconnect one of the main wires from the generator terminal to see whether any current is flowing from the generator, and follow the wires from thence to the ammeter, examining them at each terminal to see whether current is flowing by touching the disconnected wire to its terminal.

A rough check on the accuracy of the ammeter may be obtained by noting the ampere ratings of the various lights on the car and then switching them on one at a time. The reading of the ammeter should correspond to the total amperage required for the lights—see also page 410.

With the engine running and the lamps on, the ammeter may register either "discharge" or "charge," depending on the speed of the engine, the capacity of the generator with respect to the lamps, and the condition of the battery, that is, whether it is charged or not.

Unsteady reading of the ammeter may be due to a defect in the instrument, or due to loose contact or intermittent ground. See flickering lamps, pages 420 and 421.

Tests with a Volt-Ammeter.

In this instance we will refer to the volt-ammeter, as described in charts 190 and 191, and used for general shop testing work.

The tests for various troubles, such as, short circuits on the line, generator, testing coils of generator and battery cells, etc., is shown on pages 410, 402, 403, 406, 414, 453, 412.

*A Digest of Lighting Troubles.

Starting and lighting troubles are due to one or more of the following causes:

Bad contacts.
Broken connections.
Grounds.
Weak battery.

Symptoms of these various difficulties may conveniently be grouped under the following heads:

(1) Lamps.
(2) Generator.
(3) Battery.
(4) Motor.

No. 1, we will treat below. Nos. 2, 3, and 4 are covered on their respective pages as enumerated:

See page 407 for starting troubles.
See page 411 for generator troubles.
See page 422 for battery troubles.
See index for carburetor and ignition troubles.

(1) Lamps.

Lamps do not light up.—(a) Examine **fuse** block for blown fuses.

If the fuse is blown, do not replace it immediately, but look over the wiring for an accidental ground or short circuit. If the fuse in the headlight circuit blows, turn off the headlight switch until the trouble is located and removed. In looking for grounds, abrasion of the insulation on the wire, or a metallic contact between the wires, or between current-carrying part of the wiring devices and the metal of the car, should be looked for.

When the trouble has been located and corrected, then replace the blown fuse with another of the same capacity, being sure it is the proper size.

(b) If **fuse** is found **not blown,** look for open circuits, loose contacts, battery disconnected or accidentally run down, or burned out lamps.

Examine the "cutout" switch of the generator, to see that it is properly disconnecting the generator circuit from ground. This switch should be in the open position, when the engine is not running, and should be in the closed position when the generator is running at any speed over 300 to 450 r. p. m., this cut-in speed, varying slightly with the size of the generator.

(c) In case **battery is run down,** recharge it immediately, and if possible, give it a gassing charge—see page 447.

No lights or dim lights, with the engine running: there is a group of troubles which can be classified under the general head of open circuits. There are eleven of these which are prominent:

1—the generator terminal or brush connections may be loose or poor contact.

2—the wire connections to switch may be defective.

3—defective wire connections to connector terminals.

4—lamp socket terminal loose.

5—burned-out bulbs.

6—halves of connectors do not make contact.

7—bulb bases out of contact with lamp sockets.

8—loose connection on lighting switch.

9—broken wires, especially at taps.

10—joints or places subject to abrasion.

11—defective connections at the lamp.

---

*See Instruction 43 for additional "Digest of Lighting Troubles." **Remember, when testing for electrical troubles that a complete circuit is necessary** in order to have the electric current do its work.

Lamps in one circuit do not burn.—This may be caused by;

(a) The lamp is burnt out. Try another lamp in the same socket.

(b) If fuse is found blown, try the same fuse in another circuit. If the fuse is blown do not replace it immediately but look over the wiring for ground or short circuit.

If the trouble cannot be located immediately turn off the switch on the damaged circuit until the trouble has been located.

If the trouble is in a particular lamp socket, disconnect the attachment plug from this socket until the trouble can be removed and see that the removed attachment plug does not dangle in such a way, as to make short circuit on the metal of car.

(c) An open circuit, or broken connection in the wiring. Examine the places where the connections are made on that particular circuit.

(d) In case trouble is due to short circuit on some particular lamp socket, disconnect the attachment plug leading to this socket until the difficulty can be remedied.

Fuses blow repeatedly.—lamps defective —short circuits—first try new bulbs. Fuse may not be large enough capacity.

Lamps go out for an instant only.—if the lamps in one circuit act this way, there is probably a loose connection on the circuit so affected.

If all the lamps go out for an instant there is probably loose connection at one end of the wire from the generator terminal to the fuse box.

All lights burn dim,—usual trouble is loose or slightly grounded connections, or poor or corroded connection at the battery. More likely the battery simply has not had sufficient charging.

If the wiring is all right, run as much as possible with lights off so the dynamo will charge the battery at a higher rate.

If the battery continues to run down, examine cut-out. If cut-out is o. k., then test battery with switch off, for a "ground" or slight "short circuit" in the sockets, or switch. See chart 189, and fig. 6. page 413, and pages 418, 403.

If there is no ground, then test battery electrolyte, also each cell separate as per pages 416, 450.

Lamps may also be old and blackened, try new bulbs.

Lamps too bright.—Regulator evidently set for a higher voltage. Use lamps of higher voltage.

Lamps burn out often.—Due either to a poor grade lamps used, or not proper voltage or inferior grade—see page 403.

Lamps flicker and ammeter unsteady.—Loose connection in light wires. Loose connection between battery and dynamo. Loose contact at lamp bulb. Exposed wire touching frame intermittently, causing short circuit.

Lamps burn very dimly when starting pedal is used.—Battery very weak, almost discharged. Battery injured, probably one or more cells, due to lack of water. Battery terminals or ground wire not tight.

Lamps bright, engine speeded up, dim when engine slows down or idle; battery discharged or loose connection.

If possible, have the battery charged at once from an outside source.

If this cannot be done, endeavor to run with fewer lamps than normal, turned on for a few days, or until the battery voltage picks up again.

If the lights grow dim when the car is speeded up, wires reversed at dynamo.

Lamps will not light, but starter cranks engine.—Lamps burned out or filament broken. System short-circuited or open circuit, at fuse or switch.

Lamps seem to burn brightly, but fail to illuminate road sufficiently,—lamps out of focus. Rays of light directed too far upward (see "focusing" page 433.)

None of the lamps will burn—and no spark is obtained for ignition, this may be due to:

(a) Terminals of the battery are disconnected or corroded, so that they do not make good contact.

(b) Ground wire, from the battery to the chassis is disconnected or broken.

If the ignition is all right, the trouble may be due to:

(a1) Lead from the battery to the generator, disconnected or broken.

(b1) Lead from generator terminal to the fuse box is disconnected or broken.

(c1) The lamps are burned out. This is likely to happen when either of the troubles are a, b, or a1.

(d1) Battery is run down. (see battery instructions, also page 422, 416, 410.)

If one lamp burns dim, change the bulb. If the same lamp is still dim, test the wiring to the lamp. Examine lamp socket.

A great many of these troubles are found in poor connections in the lamp socket—or slight ground in this circuit.

Lamps flicker:—This trouble is usually attributed to loose connections.

It can also be caused by bad contact or an intermittent ground. For instance a contact might be just loose enough so that vibration would cause the circuit to be made and broken repeatedly.

A grounded wire might also cause this trouble by alternately making and breaking the ground connection. Every time the ground is made the light goes out because the current flows through the ground instead of through the lamp.

Obviously the trouble may be roughly located by noting whether all the lamps flicker or only one. If all do, then the trouble must be in the generator, or on the main lines running from it, and if only one does, then the trouble is in this individual circuit.

‡Reversal of Battery Terminals To Generator.

The generator connections to the battery should positivo pole of generator to positive pole of ttery and negative pole of generator to negative le of battery.

If battery is connected reversed, as would conct positive pole of generator with negative pole battery, then it would appear that this series nnection would double the voltage, but such is ot the case.

On the Remy system the battery voltage would e sufficient to influence and control the generar polarity and generator would soon reverse self—the ammeter however would read in reverse irection to what it did previously.

On other systems the field would not reverse eadily and the needle of ammeter would swing ack and forth, due to the cut-out switch vibrating. The generator in this case would build up s it normally would until it reached sufficient oltage to close the cut-out switch. The moment his was closed the strength of the field would decrease, consequently output of generator would drop until such a point the cut-out switch would automatically release, then the same action would continue causing the cut-out switch to vibrate.

In many instances, by merely holding cut-out switch down a few minutes it will cause a reversal of the polarity of the fields. However, the best plan is to connect the battery as it should be.

On the Delco late systems the polarity of generator would be reversed and no serious harm would result,

On the early Delco type which used the cut-out, the voltage of generator would drop, consequently strength of fields, similar to paragraph four.

The battery would not necessarily discharge itself if connected reversed—providing the generator immediately changed its polarity as cut-out would open circuit as usual when engine was idle. The battery would not receive a charge however until polarity of generator was reversed.

If polarity of generator did not change immediately then battery would discharge, because cut-out points would open and close repeatedly, causing a sparking until points become pitted and stuck together.

Don'ts and Do's—Read Carefully.

Always disconnect the wire from generator terminal, before disconnecting the battery, and reconnect the battery before reconnecting terminal. Otherwise the lamps may all be burned out if the engine should be started.

Don't use a piece of wire instead of a fuse.

Don't short circuit your battery with a pair of pliers or screw driver, to see if it's charged.

Don't advance spark, but retard when you start with starting motor—throttle partially open.

Don't use emery paper on your commutator; use fine sand paper.

Don't forget to see that your ignition switch, spark lever and gas lever, are all in their proper positions, before depressing the foot switch to start the engine.

Don't fail to push down the button of the foot switch to its limit.

Don't continue to crank your engine, if ignition does not take place after a few revolutions. There is something wrong with your ignition system, or the carburetor. Look for the trouble. Just turning over the engine will not help matters, but it will exhaust your battery, if continued for any length of time.

Don't allow connections on generator, battery or motor to become loose.

Don't blame the generator for every trouble you may have. As a matter of fact, 90 per cent of all troubles originate in switches or wiring connections, at the lamps, which are necessarily small and more or less liable to imperfect contact or short circuit.

Don't forget that it requires twenty times as long to restore current to the battery, as it takes to start the car. In winter, it is sometimes advisable to use starting crank to save the battery current.

Don't put oil or grease on the commutator of the generator or motor.

Don't tighten up on the silent chain drive unless the slack becomes excessive from stretching. The chain must be run with a reasonable amount of slack to prevent noise and wear.

Don't fail to lubricate the silent chain drive at frequent intervals. Noise will be eliminated and wear reduced. Keep the chain and sprockets clean, and free from dirt.

Don't run your car, if for any reason the battery is disconnected from the circuit, unless you have disconnected the chain driving the generator, or the generator itself has been removed.

Don't forget to examine your battery at intervals of about two weeks, and make certain that the electrolyte covers the top of the plates in each cell. See instruction 32.

Don't allow your battery to become loose in its box or container. Strap or wedge it tightly in position, and make certain, that the terminals cannot come into contact with anything which may cause a short circuit.

†The Starting and Lighting Storage Battery.

Chief in importance, ranks the care of the battery, owing to the fact that it is extremely sensitive to the slightest ill treatment. (see storage battery instructions relative to the construction, care, charging, etc.)

Storage batteries used for starting and lighting must have heavier terminals and parts than one used merely for lighting or ignition. This is due to the fact that a greater volume or amperes of current is drawn for starting motor and the terminals must be of sufficient size to carry this heavy quantity without heating. (see chart 201.)

A storage battery used for lighting, will operate the lights until the specific gravity (SG), is down to 1.150, whereas **a starting** battery, should not be allowed to fall below 1.225 specific gravity.

If Battery is disconnected be sure and reconnect it with same wires or terminals—otherwise reversal of current will result.

The wires should be tagged if disconnected. See "index" disconnecting battery.

Color of terminals, of a battery. The positive terminal of a battery is always of a dark color, and the negative, more a grey color. Positive terminals are usually designated, by a (P) or (+) sign and the negative by an (N) or (—) sign.

To test a wire lead from generator for its polarity, if not marked, see chart 204-A.

If sparking occurs when switch is off, and when connections to battery are being made, even the smallest spark, it is evident that a ground or short-circuit exists in either the starting motor wiring or in the wire from the battery to the lighting switch. Go carefully over the wiring again, as this must be located and corrected.

See fig. 6, page 413, note the method for testing the circuit for a ground by suddenly making contact with battery terminal with switch off, see also page 406.

---

[*] **Storage battery connections and ground**; the positive terminal of a storage battery is usually grounded to frame. This connection to frame should be filed clean and tightly drawn together with a bolt, or else soldered.

Often times poor connections at battery terminals and this ground wire, will result in dim lights and weak current supply. Always clean battery terminals with file when connecting battery. (see also pages 457 and 428). †See pages 457 and 451. ‡See also page 925.

*Starting and Lighting Battery Does Not Stay Charged—Causes.

The battery does not stay charged—This may be due to any of the following:

(a) \ ***The car is not run enough without lights or at high enough speed** for the generator to charge the battery and replace the current that is taken from it when the lamps are burning with the engine idle or running at very low speed.

(b) **A ground in the car wiring.** With the engine idle and all switches "off," disconnect the battery wire and touch it lightly on the battery terminal a few times, per fig. 6, page 413. If there is a spark produced there is a ground in the wiring between the battery, the generator, and the switch, or the magnetic switch in the regulator is not open, see also page 406.

(c) **Regulator cutout switch is not operating** properly. Examine the switch and see that it is properly connecting and disconnecting the generator circuit (see page 410). The cut-out switch should be in the open position when the engine is not running, or should stay in the closed position when the engine is running above "cut-in speed." If the switch does not close there may be oil on brushes or commutator of generator, or one of the brushes may be worn too short.

(d) **A constantly discharged battery can also be due to** an overload on the starting or lighting system, which may be caused by the leakage of current from **short-circuits** or grounds as described, by **increasing the** lamp load through the adding of **high** candlepower or lower efficiency **lamps, by adding additional apparatus to the lighting system** or to operate from battery, by the improper operation of the starting **motor or** by burning the lamps much longer **than normal.**

(e) **A discharged battery can also be due** to an internal short-circuit, as **explained on** pages 413, 410 and 416.

(f) **Generator may not be generating current** properly.

(g) **Battery may be leaking** its **solution** slightly but continually.

(h) **Cut-out points may be stuck and** when engine is operated below **an engine** speed corresponding to about 8 or 10 **miles** per hour or less the battery **discharges** through the armature of the **generator (see** pages 409, 411).

(i) **A weak battery may also be caused by low gravity electrolyte,** in which **case distilled** water should be added to bring the level ½ in. above the tops of the plates, and then the battery should be **charged. Loose** or poor connections will **cause weak** current. (see foot note, page 421.)

(j) **A weak battery may be caused by lack of charging due to the cutout points not closing** as they should.

†Remedies for Above Troubles and Hints to Save Battery Current.

(a) Have battery recharged, from an outside source. Use starting crank often as possible. Use starting motor as little as possible. In winter the starting motor is used more than in summer on account of difficult starting. Use dimmer lights instead of head lights thus saving on the current consumption. Provide a good "choker" or primer which will start engine quick.

(b) The test is mentioned above. Other tests are shown in charts 190 and 191.

(c) On some cut-outs (also called relays,) they are sealed. If adjustable, examine the points. See pages 359, 410.

(d) Quite often extra large lamps or additional electrical devices, or short-circuit in the electric horn will cause undue waste of current. Replace lamps with lower candle power and use least number possible. Spot lights are handy, but consume current, use the headlights.

(e) If the battery becomes discharged immediately after having been charged, and there are no "grounds," examine each cell, and test voltage with starter on—see pages 410, 416.

(f) Test generator as explained on page 411. Also pages 416, 410.

(g) Examine each cell carefully.

(h) This would cause a weak battery if allowed to continue for any length of time. Therefore, allowing the engine to idle, or running slowly on high gear, should not be done to any extent.

(i) Continued undercharging will result in sulphation, and the remedy is to give the battery a prolonged charge.

A weak battery is also indicated by a lowered specific gravity. When the battery is charged the gravity is 1.250, and when badly run down it drops to 1.150. Therefore, both charged and discharged conditions may be determined by measuring the specific gravity, with a hydrometer, which instrument will be fully treated under storage batteries. Don't let battery discharge in winter—it will freeze.

(j) Operate car at speed at which the cutout should close and note whether it does or not. (see pages 409, 410.)

***Note—See instruction 32-A for additional battery troubles of the starting and lighting system.**

***There is more trouble from discharged batteries in winter than in summer,** due to the fact that engines are usually more difficult to start and battery is used more. Consequently the generator does not have an opportunity to put back the current taken out—especially if car is run more at night with lights on.

The engine crank is more difficult to turn over on cold days after standing a long while, due to oil being heavy and congealed and unvaporized gasoline.

†Keeping battery charged: Keep engine tuned up so that it starts on the second or third turn. This minimizes the amount of current used in starting, and, remember, this is very large. **Be economical with lights.** Use headlights only when absolutely necessary. **Determine the car speed at which cut-out relay makes connection with the battery** and operate the car as much as possible above this speed.

If you drive much in a congested city district and stop your engine many times, you will find that your battery can be kept more nearly charged by changing gears in traffic whenever necessary instead of trying to do it all on high gear, the reason being that by changing gears you boost your engine speed so that battery is charged, while if you try to pull slowly on high you get down to a speed at which charging stops due to the opening of the cut-out.

†Disconnecting Storage Battery and Generator.**

many systems the storage battery, if dis- ected, the lights would be burnt out because **attery** acts as a **voltage regulator** and keeps **voltage** constant. Therefore if removed, the **rator** voltage would increase with speed of en- **and** burned out lamps would be the result.

page 925, explaining the meaning of "volt- and "current" regulated generators.

an example of disconnecting the generator battery, from a car, questions will be an- **ed** on a few of the leading cars.

—**What** make of generator is used?

—**Is** the regulation "voltage" or "current" **egulated?**

—**What** precaution is necessary in disconnect- **ng** battery?

—**What** precaution is necessary in disconnect- **ng** generator?

—**Would** it be possible to run engine if gen- **rator** is out of service?

—**Would** it be possible to run engine if battery **s** out of service?

—**If** both generator and battery is out of service **ould** dry cells be used?

Hudson.

—Delco single unit.

—Current regulated; third brush.

—If the battery is disconnected the motor cannot be operated.

—Disconnect the cables attached to the battery terminal of the generator and connect them firmly together. The joints should be wrapped with tape or insulated in some way to prevent any possible chance of contact with the frame. The battery circuit for the lamps will in this way be maintained. The cables connected to the shunt field terminal and to the armature terminal should also be disconnected and the ends insulated.

5—Yes. By taking the precautions noted above the battery would furnish the ignition.

6—No, the engine could not be started.

7—Yes, if the generator and storage battery are both out of service, dry cells could be used in place of storage battery.

Cadillac.

A1—Delco.

A2—Current regulated; third brush.

A3—Care should be taken to prevent short-circuit.

A4—Generator should not be removed or an adjustment made on circuit-breaker, nor any of the wires to same removed without first disconnecting battery.

A5—Yes, so long as storage battery is charged, as current for ignition would be taken directly from storage battery.
If it is desired to do this, leave the cable connecting the motor generator and storage battery attached at the storage battery end. Connect the motor generator end of the cable securely to the red wire which leads to the ammeter. Connect the black wire from the horn switch to the yellow wire which goes from the No. 2 terminal on the generator to the circuit breaker. Tape the ends of the wires connected to No. 2 and No. 3 terminals on generator separately so that they will not short circuit or ground.

A6—Never run engine with storage battery off the car or disconnected.

A7—Yes. Use 5 dry cells in series and connect as follows: First, disconnect the wire from the ignition and lighting switch to the upper terminal on the end of the ignition coil on the dash, and connect one wire from the dry cells to this terminal. The other wire from the dry cells should be grounded to some convenient point on the engine or frame where a good contact can be secured. With dry cells thus connected it is possible to start the engine by hand cranking and to run it as long as the cells will furnish current for the ignition.

Packard.

A1—Bijur.
A2—Voltage regulated.
A3—Engine should not be speeded up, as generator current would not have sufficient outlet and injure generator.
A4—Be sure and tape terminals to prevent short-circuits.
A5—Yes, from storage battery, but battery would not be recharged.
A6—Yes.
A7—Yes.

Studebaker and Saxon.

A1—Wagner.
A2—Current regulated.
A3—Generator terminal should be grounded to frame so as to prevent generator becoming damaged.
A4—Ground generator terminal.
A5—Yes, battery will supply ignition current.
A6—No.
A7—Yes.

Dodge.

A1—North East.
A2—Current regulated.
*A3—If the starter-generator is run without being connected to the storage battery, ground the terminal of the starter-generator which ordinarily is connected to the battery. Failure to do this will cause the starter-generator to overheat and may in some cases cause a great deal of damage.
A4—Ground both generator terminals. It cannot be used for either lights or ignition if battery is removed.
A5—Yes, battery will supply lights and ignition.
A6—Dry cells not recommended.

Maxwell.

A1—Simms Huff.
A2—Current regulated.
A3—Remove field wire from generator.
A4—Use shorter fan belt to drive fan if removed.
A5—Yes, from battery.
A6—No, as there is no outlet for current produced by generator and it would damage itself.
A7—Yes.

Overland.

A1—Auto-Lite.
A2—Current regulated, see page 359.
A3—Tape terminals to prevent short circuit—see also page 359.
A4—See ans. to A7.
A5—Yes.
A6—Yes—by using current for ignition, dry cells, but not from generator.
A7—Dry cells can be used. The ignition wire, or the wire that is attached to the positive terminal of the storage battery should be attached to the positive side of six dry cells, series connected, and the negative side grounded to some part of the body or car frame.
After installing the dry cells, and before starting the motor, a piece of bare copper wire should be used to ground the generator. This wire should be attached to the positive terminal on the generator to some part of the car frame, motor, or generator housing.
This will prevent the increased voltage from the generator due to no resistance from the storage battery, since it has been removed from the car, from burning out the lamps and seriously injuring the generator.

Reo.

A1—Remy.
A2—Thermostatic, see page 371.
A3—Ground two lower terminals on generator, as generator cannot be used for ignition or lights if battery is removed.
A4—Tape all terminals to prevent short circuits.
A5—Yes, until battery runs down.
A6—Not from current from generator. Dry cells could be used.
A7—Yes. If dry cells are substituted for storage battery, the two lower terminals on the generator must be connected to prevent generator burning up from high voltage which would be generated.

---

*On the Dodge where magneto was formerly used, remove fuse from generator.

†See also pages 925 and 421. **Be sure and tag all wires so will be connected back right. Battery wires must connect correctly, else dash meter will read backwards.

A Testing Bench for Starting and Lighting Systems.

The test stand is divided into two parts; that for testing the generator and that for testing the starting motor.

The layout is shown in illustration. The generator equipment is at the left of the bench and the starting motor equipment at right.

The generator is clamped to a hinged table, and driven by a one-half h. p. varible speed motor, the variation of speeds, from 600 to 1,800 r. p. m. being controlled by a rheostat.

The starting motor is supplied with current by a 6 or 12-volt battery, as the case may be.

The load is applied to the starting motor through a prony brake, regulated by a pedal and measuring the torque on a 25 lb. spring scale.

As the current flow to starting motor will be high, the ammeter will require a "shunt" permitting the measure of current flow up to 300 amperes, as described on pages 416 and 414. All wiring in connection with the starting motor, with exception of ammeter and voltmeter leads to be No. 1 flexible cable.

Testing Generator.

1—**Run generator as a motor from storage battery.** By knowing the amount of current required to run a generator known to be in good condition, and the number of revolutions per minute at which it should run, a comparison may be made with the similar operation of the generator being tested.

(a) **If an excessive amount of current** is required and the **speed** is somewhat **low**; a short circuited armature is indicated.

(b) **If speed is high**; a defective field is indicated, or bearings may be too tight.

2—**Drive generator** connected through the lamps to storage battery until from 8 to 10 amperes of current is generated.

(a) **Take the speed** of generator.

(b) **Compare this speed** with that of a generator known to be o. k.

(c) **If it is found necessary to drive generator much faster than normal,** providing brushes and commutators are in good condition; defective fields or armature are indicated. This condition shoul checked with that of the first test.

3—Not only do the above tests show e what is happening with the generat compared with a generator known t in good condition, but also current outs and control can be regulated w the required limits. Any equipment m facturer can supply the data required making these tests, or it may be obtai from a generator known to be in good dition.

Testing Starting Motor.

1—Run starting motor without any load.

(a) **A high amperage reading and slow** will indicate that bearings are either or the armature or field circuits shorted. This test may be made one, two or three cells of a storage tery supplying the current.

(b) **If current is not excessive, but** low; the connections and conditions brushes and commutator should be e ined. Likewise the brushes should adjusted.

2—**The next test is made under load,** to s whether the starting motor will deliv its full power at required speed and w the required amount of current.

(a) **For example,** a certain instrument havi a current of 135 amperes passing throu it at approximately 6 volts should tu 2000 r.p.m. and exert a torque of 1½ ft. lb. This amount, if the pulley were 2 ft. in diameter, would register 1½ lb. on the spring scale. However, it is not advis able to use so large a pulley, and by u ing a 6-in. pulley the spring scale readin is multiplied by four, giving the readin required.

(b) **In making the test** the motor is starte and sufficient pressure applied to the pedal to bring the spring scale to the re quired reading. The ampere voltage an speed readings are taken and compare with the similar readings of a startin motor known to be in good condition. A low reading indicates defective armatur or field.

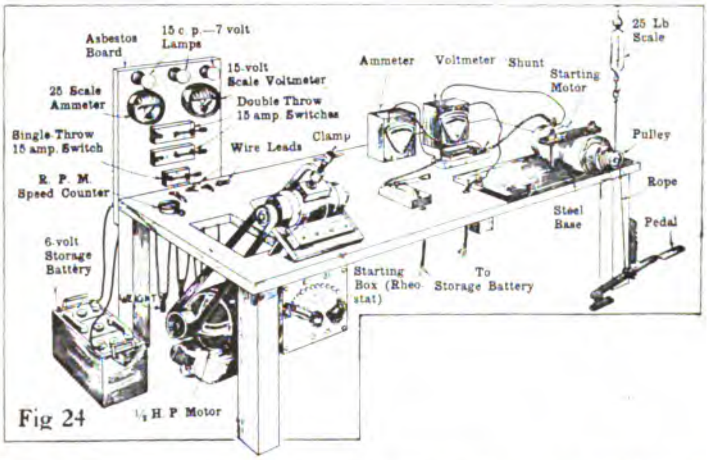


Fig 24

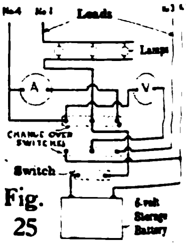


Fig. 25

Diagram of wiring for the test board shown in fig. 24.

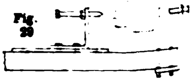


Fig. 26

Simple jig on bench to support armature during repair.

CHART NO. 192-A—Electrical Testing Outfit for Starting Motors, and Generators. See also pag 418, 410, 406, 404, 416, 402, 403.

(Motor World.)

INSTRUCTION No. 30.

IRING OF A CAR FOR STARTING, GENERATING AND LIGHTING SYSTEMS: Single, Two and Three Wire Systems. Wiring Starting Motor, Generator and Lighting Circuit. Size Wire to Use. Comparison of Current Carried in Starting and Generator Circuit. Wire Accessories.

he single wire system is also called the rounded return'' system because one e which returns to complete the circuit grounded to the frame of the car as wn at A, chart 193.

he single wire or grounded return sys- n is used on seventy-five per cent of the s. In this system only one main wire insulated, the other being connected to e frame of car which acts as the return re.

In this system the negative (—) termi- l of the battery is connected to the elec- ical units and lamps through switches, and e positive (+) terminal is connected to e metal frame of the car. As the positive (+) terminal of each unit and one terminal of each lamp is also connected to the frame either through mounting or by cable, the circuit is completed when the switch is closed. See A, chart 193.

The two wire system: Where wires are not grounded but are run independent of the frame or ground connections, it is termed a two wire system. A simple explanation is shown at B, chart 193. In this system both wires are insulated and kept away from the frame.

The three wire system is shown at, (C). This system is sometimes employed where 12 volt or higher voltage batteries are used and where it is desirable to use 6 volt lamps. See also chart 205-C.

Kinds of Wire Generally Used.

Primary wire is used for **low tension** or oltage, as **ignition,** from battery to coil, nd coil to timer (see page 240) and for **ghting.** It is usually flexible, consisting f several strands of wire. When used for ighting it can be "duplex" or even four ires together, and is usually encased in etal armor for protection.

1—

PRIMARY WIRE—Single

2—

PRIMARY WIRE—Duplex

3—

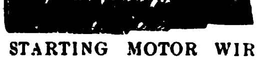
PRIMARY WIRE in metal armor

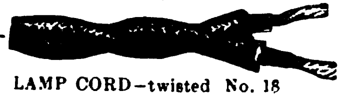
4—

PRIMARY WIRE metal armor

5—

SECONDARY CABLE—note heavy insulation

6—

STARTING MOTOR WIRE note heavy wire

7—

LAMP CORD—twisted No. 18

Secondary cable is used for **high tension** ignition current. The wire is small but insulation heavy (see page 240).

Starting motor wire is very heavy, being several times the size of the secondary cable, but insulation is not so heavy. This is due to the fact that it does not carry a high voltage, only 6 to 24 volts, whereas secondary cable carries a voltage high enough to jump a gap.

The starting motor wire carries a large **quantity** or **amperage** of current, for instance, the wire runnig from the storage battery to the starting motor, when first starting, must carry from 80 to sometimes 400 amperes; or quantity of current, owing to the size of motor. This is used only for a few seconds. But, large wires must necessarily be used to carry this great quantity, even for a few seconds. **Compare the size of the starting motor wire (6, illustration to the left) with that of the primary wire (1), which can be used for generator** or lighting. Note the difference in size of wire.

The wires running from the generator to the storage battery are much smaller, as the quantity of current which passes through this wire is only 5 to 25 amperes.

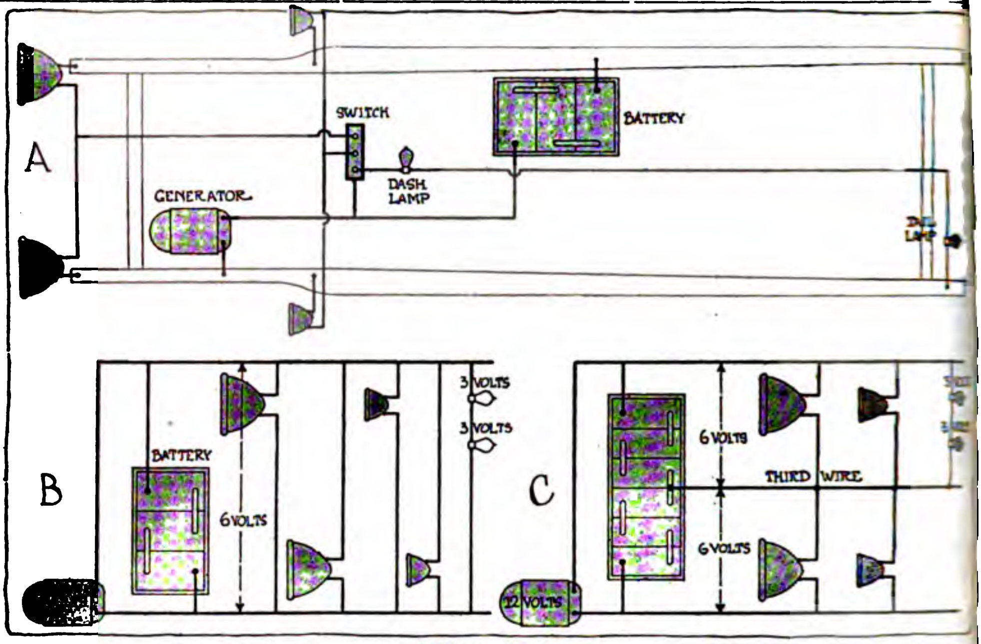
As a **comparison;** imagine water pipes. If you desired to pass 150 gallons of water through a pipe in one hour, it would require a larger pipe, than one where you passed only 25 gallons per hour.

Size Wire to Use.

Generator to battery	no. 10
Battery to starter	no. 1 or 2
Headlights	no. 12 or 14
Tail light	no. 14
***Ignition** (primary)	no. 14
Ignition (secondary)	no. 14 or 16
Horn	no. 18

---

†Sizes vary slightly according to length of car and number and size of lights and size of engine and starting motor, etc. But this is an average. *See page 240.



Wiring Systems.

There are three general systems employed for wiring a car; the single wire or ground return, and the two and three wire system.

A—Shows the "single wire" system; one wire insulated from the frame and frame serves as a wire. One wire, usually the positive terminal of battery and generator is connected to the metal frame. Note where the storage battery connects to frame. This connection is made by a lead lug from the battery and tightly bolted to a cleaned surface with copper washers on each side—the connection must be water proof.

B—Shows the "two wire" plan, where both wires are insulated and kept away from frame.

C—The "three wire" system; consists of three wires, one known as the "neutral." Note in this illustration the storage battery is a 6 cell or 12 volt battery and the third wire divides three cells to a circuit, making 6 volts for each side of the third wire.

It is important that the lights or load be equalized, for if three of the six cells are worked more than the other three, and both sets are charged from the same source and at the same rate, one set would get more charge than the other. When the load is properly balanced there will be no flow of current through the neutral, which is the reason for so calling it.

***Wiring Accessories.**

The coupling box (fig. 6) provides a convenient and easily separable means for connecting together the wiring on the chassis and on the car body.

The junction box (fig. 7) is used to connect a wire running in a different direction and is much better than making the usual connections. Taping the joints or soldering is not necessary. It also affords a convenient point from which to test.

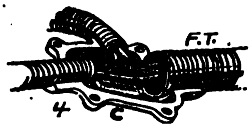


Fig. 4. Showing wires run through metal, flexible tubing or conduit.

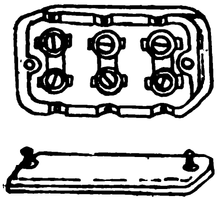


Fig. 6—Coupling box.

The lighting switch; (fig. 9), called a "*gang*" switch—is a "two gang" type. The lower or light colored push is for lights, and the upper (dark) push is "off." It is usually placed flush on the dash.

Wire used for electric lights ought to be protected from oil and dampness and from the frame. The best wire has insulation of an outer covering of heavy braid, specially impregnated, an intermediate layer of treated cloth, and an inner covering of soft rubber. The copper wire itself is made of fine strands and is called flexible, stranded wire.

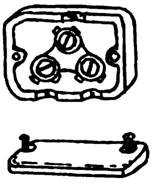


Fig. 7—Junction box.

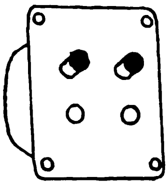


Fig. 9—Two circuit lighting switch.

Conduits (fig. 4); provide a complete enclosed runway for wires from which they can be drawn if necessary and new wires installed. It affords protection from mechanical injury such as bruises, etc. The conduit is made of galvanized steel and is flexible (fig. 4).

Flexible steel armored cable is now very popular. It can be purchased containing one or more wires. The wires cannot be withdrawn.

CHART NO. 193—The Single or Grounded Return. Two Wire and Three Wire Principle. White Accessories. *See also page 428.

**Starting Motor Amperage.

The starting motor consumes a quantity of current as stated on pages 425 and 327—but only for a few seconds—The exact amount of current consumed and the time required to put back the amount used, with generator, varies in different makes—see pages 410, 416.

To those not familiar with electricity, the question would arise, **how can the starting motor receive 120 amperes of current, if the generator which recharges the battery, does not give but 7 to 15 amperes to the battery when charging it.**

Taking for example, a storage battery of 120 ampere hour capacity. It would deliver at the rate of 120 amperes for one hour, or at the rate of one ampere, for 120 hours, or any proportional amount accordingly (varies according to discharge—see page 441 and 827).

**Now, assuming that when current is first applied by switch the quantity is 120 amperes; then after motor has started, the current consumption drops to 65 amperes. This would give us an average of say, 55 amperes used. The time for the operation, say was 10 seconds.

Assuming the average draw on the battery was 80 amperes for 10 seconds, the ampere-hours consumed is as follows: 10 seconds equal 1/6 minutes, or 1/360 hours, and 1/360 of 80 amperes equal 80/360 ampere-hours or .22 ampere-hour, per start.

Car running at 15 miles per hour generator would charge battery, say—at the rate of 7.5 amperes per hour. It then requires as long to recharge the battery per start as .22 is contained times in 7.5 which is 30 times. In other words the generator is capable of putting back into the battery, 30 times as much current in one hour as was used for starting and put back the exact amount used in 1/30 of an hour. or 2 minutes.

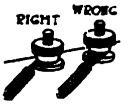
Another point; how can a storage battery of 120 ampere hour capacity deliver 475 amperes, per page 327? A good battery is capable of delivering an overload for a fraction of a second—but only good batteries can stand this—this is one reason why batgenerator, varies in different makse—see pages 410, 416.

†Wire Connections.

The connections, in electric wiring should be soldered. The unseldered connection may work as good as a soldered connection at the time of being made, but the resistance always increases.

Soldering paste; do not use acid when soldering electrical apparatus or wiring, as the acid is an electrical conductor and it also destroys the insulation. It is much better to use a **non-corrosive soldering paste.**

Tape; do not use friction tape on high tension wiring or on other wiring where the grease or oil can get to it. It is much better to use **linen tape and shellac.** Friction tape will not insulate ignition current, neither will it hold when oily.



When placing a wire terminal under a terminal nut, twist the wire in direction nut turns.

When connecting a wire under a screw or nut—use a washer, (copper or brass).

Wiring Troubles.

Are numerous if not properly done. All connections must be soldered. Oil and grease destroy insulation. Moving parts must not touch wires. Protect wires from chafing. Avoid frayed ends. Tape all connections. Connections and terminals must be kept tight. Vibration often jars them loose. See foot note page 457 and page 241.

Ampere Capacity of Wire.

The size wire to use, depends upon the amount of current that must flow through it, and the length of the wire. The longer the wire the greater the resistance offered to the flow of current. Therefore there will be too much drop in voltage at the wire terminus, if it is not of sufficient size.

A conductor must be large enough to carry the required amount of current to a certain point with less than 4% drop.

Most all automobiles are using a single wire system and the length of wire is seldom over ten or twelve feet long.

The sizes given on page 425 for generator, starter, lighting and ignition is the average size used on most cars.

The carrying capacity of wires (*B & S gauge)—as given by the National Board of Underwriters for rubber covered wire is as follows:

No. 18	B & S gauge......	3 amperes.
No. 16	B & S gauge......	6 amperes.
No. 14	B & S gauge......	15 amperes.
No. 12	B & S gauge......	20 amperes.
No. 10	B & S gauge......	25 amperes.
No. 8	B & S gauge......	35 amperes.
No. 6	B & S gauge......	50 amperes.
No. 4	B & S gauge......	70 amperes.
No. 3	B & S gauge......	80 amperes.
No. 2	B & S gauge......	90 amperes.
No. 1	B & S gauge......	100 amperes.
No. 1 & 0	B & S gauge......	125 amperes.
No. 2 & 0	B & S gauge......	150 amperes.

Higher the number, smaller the wires. No. 0 is many times larger than No. 18. No. 18 is .04 or 3/64" di.; No. 0 is .32 or 5/16" di.

Accessories and Switches.

Some of the accessories for wiring a car are given on pages 426 and 428.

Ignition switches are usually placed on the cowl (dash) of car and operated with a key.

Starting motor switches are usually operated by the foot. See page 408 for diagram. The ignition switch must be "on" when engine is started.

Lighting switches are usually placed on the cowl (dash) of car and are of the push button type, per fig. 2, page 385 and fig. 9, page 426.

A touring switch is sometimes provided on a car for the purpose of allowing the operator to discontinue the charge from generator to storage battery when car is on a long tour running mostly during the day.

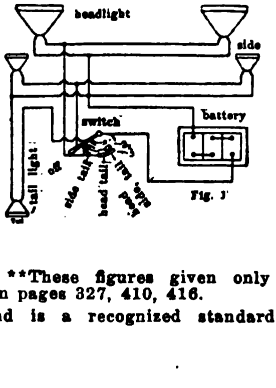


Fig. 1

To give the reader an idea of the various kinds of connections which may be made by one switch, see fig. 1. The contacts have been numbered 1, 2, 3, and 4. If 1 and 4 connect, side and tail lights are on. If 1, 2 and 3 connect, then side, tail and headlights are on.

---

*See pages 240 and 425. †See pages 422 and 428. **These figures given only as an example—a nearer correct ampere discharge would be as given on pages 327, 410, 416.

*B & S gauge, means Brown and Sharpe gauge and is a recognized standard.

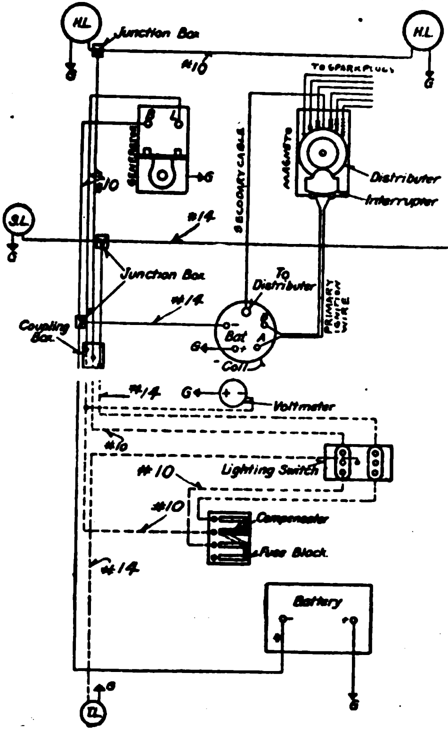


Fig. 2. Size of wires to use, indicated by number. G means grounded, TL means tail light, SL sidelight, HL headlight.

Wiring shown full run along chassis. Dotted lines are wires to be attached to body.

Wiring a Car.

The size of wires to use for ignition, **ing, and generator** is shown in the illustr

The kind of wire to use for each, i plained on pages 425 and 240. The wi **the lights, and other wires running along** **of the frame,** or near metal parts, shoul the flexible "armored" type, see page

The purpose of the coupling box, fuse b **and junction box** is explained on pages 348 and this page.

Wiring the Starting Motor.

This wire must be large, especially with a starting motor. Use No. 00 if a long distance large car, or No. 1 or 2. The No. 00 measure in. di. over the copper strands. Use flexible ber covered wire.

Good connections are very essential for start motor to switch and battery. The ends of should be cleaned and "tinned," by dipping in molten solder and then good clean, strong terminals soldered thereto for attaching to gr on frame and to the switch. The terminals the selves should be cleaned also the part to it is attached, and then draw up snugly.

Battery Connections.

The ends of wires connecting with the should be treated in the same manner, but lugs to fit the battery terminals should be used. is important that both the terminal of battery, side, and lug, be scraped and cleaned good drawn tight. The acid tends to corrode the minals, hence reason for clean

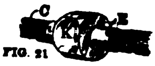


FIG. 21

If it is necessary to have coupling for this large wire, method is shown in fig. 21. regular brass pipe coupling (K) could be used. The two halves of the coupling E, have ends of the wires C, sweated into them. The coupling should be well taped if near metal-see also page 408.

Note: When using stranded wire on any part of a car, sometimes one strand will loose from the others and cause a short circuit. Always twist and solder ends of strand wires.

Fuses.

Fuses are very important, particularly when the grounded or single wire system is used. The purpose of a fuse is to melt and open the circuit in case of a short circuit and prevent discharge of battery—see pages 412, 413 for meaning of "short-circuit."

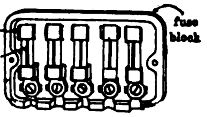


Fig. 6

FIG. 3

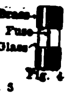


Fig. 4

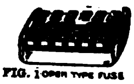


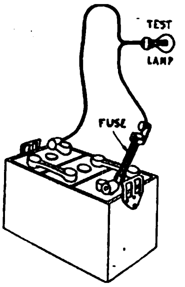
FIG. 1 OPEN TYPE FUSE

FIG. 2

les

A fuse block (fig. 6), is usually placed on the inside of dash of a car, to which the different wires are connected. The fuse is then in series with circuit. If a fuse melts then it is an easy matter to insert another fuse of which extras should be carried.

There are three types of fuses, the cartridge type fig. 3; the visible type fig. 4; and the open type fig. 2. The visible type will instantly show when burned out, whereas in the cartridge type a hole will be blown in the side of shell. The cartridge and visible types can be slipped into place in the "fuse clip," fig. 6, by hand, the open type requires a screw driver and is placed in block fig. 1. Fuse shown in fig. 4, is the type in general use.



Testing a fuse.

Testing: with types fuses which are not posed, if suspected of ing blown, they can tested with the test lig as shown below.

The capacity of the fu in each circuit, should **as follows:** Side light 3 to 5 amperes; head lights, 15 amperes; extra circuits when provided 15 amperes. The extra circuit may be used for dome or pillar light horn and so forth, as desired.

In other words, the size of the fuse is determined by the amount of current that is to pass through If the fuse is to be placed in the head light and tail light circuit; and this circuit used 5½ amperes a 10 ampere fuse is ample protection.

Compensator: The small cylindrical-wound re sistance (B), incorporated with the fuse block fig. 4, page 348, is the "ballast resistor." It pro tects the side lights from over-voltage when the headlights are not lighted, see also page 347.

***The circuit breaker,** is a device used similar to a circuit breaker on a street car, but of lighter construction. It is sometimes used in the place of fuses.

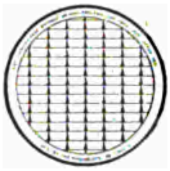
A fuse is not used with the starting motor, see page 408.

CHART NO. 194—Wiring the Starting Motor. Size Wire to Use for Motor, Generator and Lig Connections. Also see page 240 for Ignition Wiring. **Fuses.**

B

C

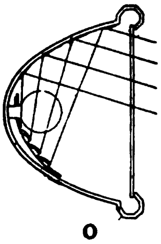
D



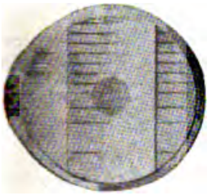
F

G

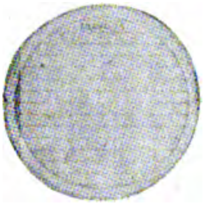
I



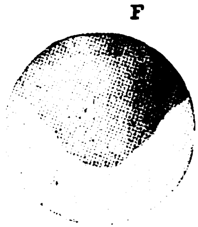
O



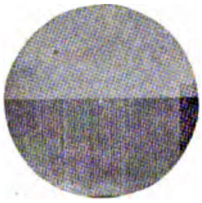
K



L



M



N

P

Classification of Anti Glare Devices.

A, B, C and D, are "diffusing" type lenses. As these devices scatter the light in every direction, the adjustment of the headlamp has little effect on the road illumination. Both the light and the glare will be a little stronger if focus is for a straight beam.

A, Warner: Both sides of glass covered with small lenses. Adjusting focus for straight beams for best lighting—see fig. 65, page 433.

B, Prismolite: Front of glass covered with small pyramids except small spot near center. Adjust focus straight beam.

C, Morelight: Front of glass covered with short cylinders, arranged in circles. Adjust focus for straight beam.

D, Stewart: Cup fitting around bulb. Outside covered with small lenses. Inside with ribs. Adjust for straight beam.

F, G, H, I, are "deflecting" type of lenses, which are intended to be used with a straight beam. In making adjustments, adjust per plain glass adjustment, page 435, except lamp must be moved to the point in reflector which gives the smallest point of light on the screen or wall, instead of making the spot 3 ft. in di.

F, Sun Ray: Horizontal prisms throw light on center of road. Small triangular prisms throw a little light along sides of road. Adjust for straight beam.

G, Conaphore: Horizonal prisms throw light on center of road, cylinders in center throw a soft light along sides of road. Adjust for straight beam.

H, Macbeth: Horizontal prisms throw light on center of road and cylinders on inside, spread a little of it along the side. Hood at top cuts off light from that part of lens. Adjust for straight beam—see fig. 66, page 433.

I, Holophane: Circular prisms at bottom throw light on road and give quite a spread. Horizontal prisms and vertical cylinders at top throw diffused light along side of road. Adjust for straight beam.

K, L, M, N, O, P: Are "deflecting" type lens designed to be used with a spread or crossed beam, depending on whether a part of the lens which bends the glare rays down is located at the top or bottom of the lens. The focus is adjusted to give a beam having some spread. Most of these devices depend more on the width given to the beam by the reflector than they do on cylinders, or other devices to add to the spread. On this account, these devices are apt to give a little greater proportion of diffused light along the sides of the road and a little less distance than devices which are used with a straight beam. The cut-off of light at the height limit is likely to be not quite so sharp as with those just mentioned, on account of parts of the beam being bent more than others. On this account it may be necessary to give the beam a considerable downward slant to bring the bright light below the glare level. This, of course, will shorten up the distance to which the road will be shown.

K, Osgood: Horizontal prisms on back of lens throw light down on road. Cylindrical section on center of front of lens is intended to add slightly to spread of light. Adjust focus for spreading beam.

L, Legalite: Horizontal prisms at top and bottom bend light down on road prisms in center; do not affect light much. Outer face is a reverse cylinder to give some spread to light. Adjust focus for a very slightly spreading beam.

M, Noglare: The ribs or upper part of lens spread the light to each side. The plain surface below is slightly frosted and gives a diffused light down the road. Adjust focus for crossed beam.

N, Saferlight: Horizontal prisms on upper half throw light down on road. Vertical prisms on lower half spread diffused light toward side. Adjust focus for spreading beam.

O, Letts deflector: A deflecting device. The corrugated reflector is placed below the lamp and changes the angle of the light striking the reflector so that all the rays are sent down on the road Very little spread light on the road. Adjust focus for crossed rays.

P, Fractor: A deflecting device. The prisms on the glass cup which is placed below the lamp change the angle of the light striking the reflector so that all of it is sent down on the road. Adjust for crossed beam.

With any of the deflecting devices it is best to make the adjustment for either spread, crossed or straight beam, while the plain glass is still in place in your headlamp.

CHART NO. 196—Classification of Anti-Glare Lens.

Chart No. 195 on page 430. See page 435 for address of manufacturers. **Fuses,** see page 428.

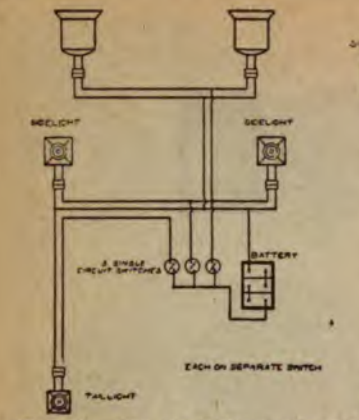


Fig. 10—Plan for lighting the tail light, head light, sidelights.

Material necessary: Electric globes to attach to two sidelights; fittings for two headlights; fittings for one tail light; one 3-circuit push button switch; 35 feet flexible rubber covered duplex No. 12 stranded wire; 10 feet rubber covered No. 12 flexible single wire; 2 Mazda Tungsten electric globes of 15 c. p. (headlights); 2 Mazda Tungsten electric of 4 or 6 c. p. (sidelights); 1 Mazda Tungsten electric globe 2 or 4 c. p. (tail light). Smaller the c. p. the less current consumed.

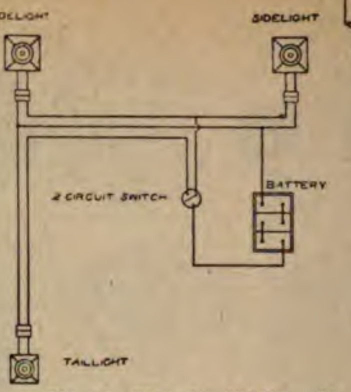


Fig 11—Plan for lighting side lights and tail light (separately).

Material necessary: One special two-circuit push button switch; 20 feet rubber covered duplex wire No. 12; 6 feet rubber covered single wire No. 12; 1-6 volt Tungsten lamp for tail light; 2 6-volt Tungsten lamps for side lights; fitting for side and tail lamps to take the electric socket.

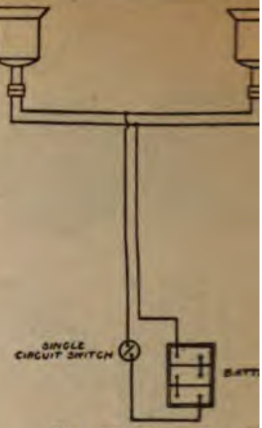


Fig. 12—Plan for li
ing the head lights onl

Material necessary:
tings for two head lig
12 feet rubber-covered
plex wire No. 12, stran
6 feet rubber-covered si
wire No. 12 flexible; 2
volt Tungsten lamps; 1
gle circuit push but
switch.

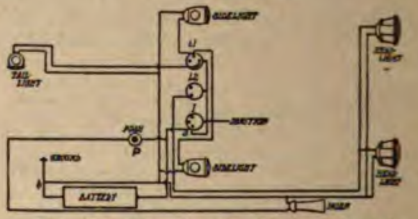


Fig. 13—Plan for attaching an electric horn to the lighting battery. The horn is operated by pressing the push button (P).

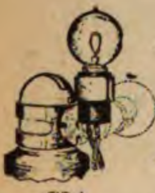


FIG. 1

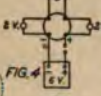


FIG. 4

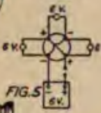


FIG. 5

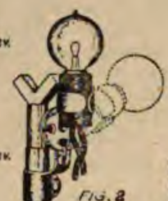


FIG. 2

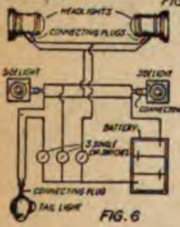


FIG. 6

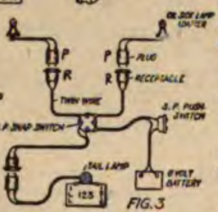
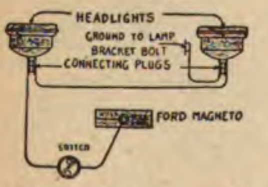


FIG. 3



Method of connecting wires to light a Ford car (from the Ford inductor type of magneto).

See Ford supplement for speed of Ford magneto. 2—9-volt, 2-ampere lamps are usually placed in series.

Fig 1 to 6—Equipping the gas and oil lights with elect
lights: The first thing to decide is whether the oil or
lamps shall be retained and converted into electric, or wheth
these lamps shall be replaced by straight electric ligh
If the original lamps are retained the change may be ma
by using an adapter (fig. 1 and 2) constructed to fit eith
an oil or a gas burner and holding an electric lamp socket.

By using a double-pole snap switch and turning it to
''off'' position, Fig. 4, two-volt lamps may be used for si
and tail lights, the three lamps being thus placed in ser
with the six-volt storage battery.

By turning the double-pole switch to the ''on'' positi
the lamps are placed in parallel, fig. 5, and six-volt lam
must be provided.

A single-pole snap switch connected in near the batte
enables the driver to turn off all the lights at once.

Another plan in which five lights and three single-pole sn
switches are used, is shown in fig. 6. The two headlig
are controlled by one switch, the side lights by another a
the tail light by a third switch.

Where joints are made the wires should be scraped cle
and after soldering should be taped with a layer of rubb
tape, then covered with friction-tape.

Fig. 1 shows an ''**adapter**'' or a device made for an
lamp, and fig. 2 as adapted to the gas burner. If the oil
gas lamps are entirely discarded and new lamps put in pla
these may be connected by **plugs** (P) and **receptacles** (R)
the permanent wire of the circuit, the plug being pulled
in case it is necessary to repair or detach a lamp. The wi
lamps, plugs, switches, etc., may be purchased from manuf
turers complete, with directions and diagram for installati

The wiring from the battery through the switches **must**
governed by the driver's desired control of the lights.

Fig. 3 shows one plan of **wiring** in which two side lig
and a tail light are provided, in the wiring of which plu
(P) and (R) receptacles are used so that the wires can
easily disconnected.

CHART NO. 195—Electric Light Wiring with an Independent Storage Battery, Where Generat
not Provided on Car—see chart 205C for connecting 12, 18 and 24 volt storage batterie
6 and 12 volt circuits. Also see page 429 for switch connections. **Equipping Oil and**
Lamps with Electric Lights.

Chart 196 is on page 429.

INSTRUCTION No. 31

LIGHTING A CAR: Electric Lighting, Gas Lighting, Oil.

There are three methods for lighting a car: Acetylene gas, electricity and kerosene oil.

The gas light can be produced from carbide in a "generator" or it can be stored in a "gas tank" and carried on the car.

Electric lights are supplied with electricity from a storage battery. When the storage battery runs down, it can be recharged from an outside source, or from a dynamo, run from the engine.

*The old style "carbon filament" in the electric globe, consumed so much current it was difficult to obtain a storage battery in a reasonable size and weight which would supply current for any length of time. The filament in the "Tungsten Mazda" globe reduces the current consumption and is not liable to break with the usual motor car vibration.

Lights on the car may be divided into those which are required by law (headlamps and rear lamps) and those which add to the convenience and comfort of the driver and his passengers.

Although some of the older pleasure cars and some trucks and other slow moving vehicles are still equipped with gas or kerosene lamps, **electricity is the standard method of car lighting** at the present time.

It is well worth knowing that any oil lamp can be quickly and inexpensively convered to electric by obtaining "adapters" from any of the accessory dealers. See chart 195.

Automobile Electric Lighting Systems.

There are three methods of furnishing current for car lighting;

(1) Independent storage battery system.
(2) Generator and battery system.
(3) Independent generator system.

(1) Where an independent storage battery system is used the capacity of the battery must be great enough to run the headlamps and rear lamps for a reasonable time before the battery has to be recharged.

From the lamp table page 434, we find that a current consumption of 7.85 ampere is required for headlamps and rear and dash lamps, the equipment of the average car.

A 100 ampere hour ‡**lighting** battery would run these lights for about twelve hours steady burning.† Under average conditions this would mean that the battery would have to be recharged about once a week. A 120 or 150 amp. hour battery will not cost much more than a 100 ampere hour and will give better service.

(2) Generator and Battery System.

The advantage of this system is that it automatically keeps the battery charged and permits more current to be used for lighting without danger of running down the battery while on the road. An example is shown on page 343 and 342.

(3) Independent Generator System.

The Ford as an example: The generator in this system delivers alternating current which is used for both lighting and ignition. Battery cannot be charged with alternating current, and on this account the lights can only be run when the generator is running and the strength of the light varies with the speed of the engine unless some type of regulator is installed.

This system is used only on Ford cars, page 265.

Another type of magneto which, if run fast enough will light electric lamps is the inductor type magneto, per fig. 8, page 256, or fig. 4, page 264. The "shuttle" type armature magneto will not light lamps.

Candle Power, Voltage and Amperage of Electric Lamps.

The candle power of a lamp is expressed as c. p. Alhough we speak of a lamp as being 24 c. p., we really refer to the spherical c. p. This means that 24 c. p. is sent out in every direction. **A reflector does not increase the brilliancy** of the light from the filament, it simply takes the total amount of light which is thrown in all directions, and **concentrates** it in one direction. For instance, with a "spreading beam" the brilliancy is not as intense as if a "straight beam."—see page 433.

The voltage is usually that of the battery, but quite often to save the lamp from burning out, a lamp of one or two volts higher is used. For instance, if 6 volt lamp is used on a lighting circuit using a 6 volt battery the light would be bright as long as battery was fully charged. If a generator is used to charge the battery and supply current for the lights when car is running over 10 or 15 m. p. h., then the probabilities are the generator would develop a slightly higher voltage than the battery—result would be that the higher voltage would increase the brilliancy of the lamps and cause them to burn out quicker than if voltage was exact or less than that of lamp. Therefore, quite often higher voltage lamps are used, say 1 or 2 volts higher.

The amperage or quantity of current consumed is governed by the candle power of the lamp—the c. p. averages from 2 to 32. The higher the candle power the more voluminous is the light—if voltage or pressure is in accordance with that of the lamp—therefore the higher the c. p. the more current or amperes consumed per hour.

Watts: if you multiply the volts by the amperes the result is expressed in "watts." For instance: 6 volts by 2 amperes, gives 12 watts (there are 746 watts to a horse power).

Where Lamps are Placed.

Head lamps of which there are two, are usually connected in parallel and the candle power varies from 17 o 32 c. p. each.

****Side lamps**, one on each side, usually connected in parallel, average 5 or 6 c. p.

Spot lamp—only one is used, usually a nitrogen lamp of 20 or 32 c. p.

Rear lamp also called tail lamp, always with a red lens in rear and white light to side, to illuminate the license number, is usually 2 c. p.

The tail light and instrument lamp are usually connected in series, as shown at A, page 426. If the rear lamp should burn out, the instrument lamp would not burn and vice versa.

This is an advantage, because the law requires that rear light burn during the night. Being unable to tell from the seat if rear light should fail, this method is used. **The voltage** is just one half of that of the regular lighting circuit when connected in series.

*__The carbon filament lamp__ is the old style lamp using a filament chemically treated and in a vacuum. **Electric lighting troubles**, see page 419. †See page 441. ‡**A lighting battery** (120 to 150 amp. hour capacity) can be used for both lights and ignition, but an **ignition battery** is usually but 60 ampere hour capacity. **A starting motor battery** can be used for lights, ignition and starting, but due to the great quantity of current reuired for starting motor the connections are heavier.

**__Side lamps are seldom used__, but small 5 or 6 c. p. bulbs are used in the headlamps for city driving and are often termed "dimmer lamps."

Step lamp—two of which are sometimes placed just below the doors, are usually 5 c. p.

Dash or instrument lamp, placed over the instruments, as the speedometer, ammeter,—2 c. p.

Inspection or trouble lamp—is a lamp and extension cord, carried under the seat and in case of need is connected in dash lamp socket—5 c. p.

Tonneau lamp—back of front seat—5 c. p.

Dome lamp—placed in ceiling of car—5 c. p.

Pillar lamps—usually two, placed on rear pillars, one on each side in rear of car—5 c. p.

It is advisable to use the best grade lamp, as low a candle power, and as few lights as possible if the battery does not get sufficient charging from the generator.

Automobile Electric Lamp Bulbs.

‡Two types of lamps are used for car lighting; the **vacuum** type, usually known as Mazda B, and the **nitrogen gas filled** lamp known as the Mazda C.

The source of light is the fine wire at the center of the lamp bulb, known as the **filament**. The current heats this wire white hot. If bulb was designed for 6 volts and circuit was 12 volts, then this wire would become so white it would burn up. If designed for 12 volts and circuit was 6 volts, the filament would be yellow and dim.

The voltage lamp to use depends upon the voltage of system. If you do not know this, count the cells of storage battery, each cell gives 2 volts—or see table, page 434.

Mazda B lamps page 434, usually have this wire or "filament" made up in the form of a spiral about 3/16 of an inch long, and 1/8 of an inch in diameter. This gives a uniform distribution of light all around the spiral.

Mazda C lamps page 434, usually have the filament made up in the form of an inverted V. In most type C lamps the V is about 1/8 of an inch high and about the same distance across the base. Some makers of type C lamps make the V about 3/16 in. long and 1/8 in. across the base. This form gives a much better distribution of light than the short V.

The Mazda "C" lamp is brighter and gives more c. p. for same amperage consumption, but is more sensitive to voltage variations—see foot note.

Note—As the lamps become older, the current consumption increases. If the glass of the lamp bulb is blackened or the filament bends down if less than its rated (c. p.) is being used, it will be best to replace the lamp bulbs.

Standard Lamp Sizes.

The Mazda B lamp, page 434, is designed for all lights, as rear, side, head. It is made in 6 to 8 volt, 12 to 16 volt and 9 volt for the Ford.

The Mazda C lamp, page 434, is designed for headlights and spot lights and is made in 6 to 8 volt, 12 to 16 volt and 9 volt for the Ford.

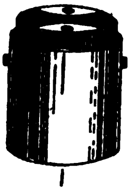
Candle power of above lamps are given in table page 434.

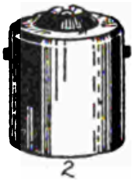
Where 24 c. p. or less is used in headlamps, the type B will usually give the best satisfaction, even though they take 20 per cent more current, due to the sensitiveness of the C lamp, as per foot note. The spiral filament of the B lamp also gives a better distribution of light than the C with a **short** filament.

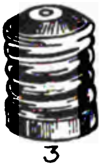
Where more than 24 c. p. is desired, the type C must be used, but those with a long V are preferable.

Types of Lamp Bases.

The lamp base is that part which fits into the socket. There are four types as explained under the illustration. The illustrations are full size.


1


2


3

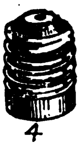

4

Fig. 1—Double contact bayonet base.
Fig. 2—Single contact bayonet base.
Fig. 3—Candelabra screw base.
Fig. 4—Miniature base.

Figs. 1 and 2 are the two types used for automobile work, are also known as the "Ediswan" DC and SC base; (DC meaning double contact and SC, single contact, also designated as D and S, also E. D. and E. S.)

Fig. 1—is used where cars are equipped with the "two wire" system.

Fig. 2—For "single wire" or grounded return.

Figs. 3 and 4—Seldom used for automobile work—used extensively for decorating purposes.

Lamps must be selected to correspond to the socket used.

Adapters consisting of small fibre discs with metal inserts can be secured at small cost and will enable both kinds of bases to be used in either kind of socket.

For voltage and base used on the different cars see page 434.

Headlamp Adjustments.

The light you get on the road will depend on the candle power you get from the lamp in the reflector; on the focus or adjustment of the lamp in relation to the reflector; and on the direction in which the headlamp itself points.

Different Focusing Adjustments.

Getting the lamp bulb in the proper relation to the reflector to give the best light on the road is called focusing. All headlamps are provided with some means of moving the lamp bulb back and forth along the center line of the reflector which line is called the axis. The four types of adjustments, figs. 6, 7, 8 and 9, shown, should cover practically all of the headlamps used.

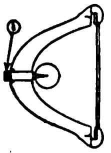


Fig. 6.

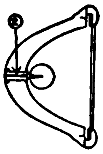


Fig. 7.

Fig. 6: Has an adjusting screw or knob near the center, on the rear of the headlight shell. The lamp bulb is moved forward by turning the screw or knob (1) to the left and backward by turning it to the right.

Fig. 7: The lamp is held in place by a ratchet device (2). The lamp is moved forward or back by grasping the bulb and either turning the bulb to the right or by pressing it to one side or the other to disengage the ratchet, and then pulling or pushing the lamp in its socket to the next notch in the ratchet. If the lamp doesn't move easily, remove reflector and see how ratchet works.

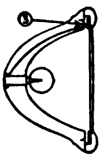


Fig. 8.

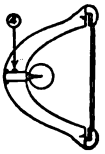


Fig. 9.

Fig. 8: The adjustment is made by turning the large screw (3) in the rim of headlight front just at the edge of the reflector. By turning this screw to the right it will move the lamp forward in the reflector. Turning it to the left moves it backward in the reflector.

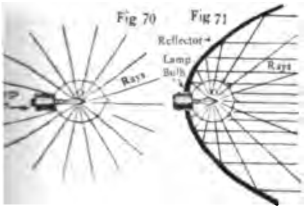
Fig. 9: The lamp is held in place by a set screw (4) in back of the reflector. When the set screw is loosened, the lamp may be moved backward or forward. The set screw must be tightened securely to hold the lamp in place.

---

‡The vacuum lamp uses a "Tungsten" filament instead of a "carbon" filament. The air is withdrawn from bulb hence a vacuum. **The gas filled** lamp also uses a Tungsten filament but the bulb is treated with nitrogen gas which increases the brilliancy by increasing heating intensity of the filament. For this reason the "gas filled" lamp is very sensitive to increase of voltage and is best adapted for "constant voltage" regulated generators—see page 925.

Relation of Focus to Light on the Road.

parabolic type of reflector, made of tal with a highly polished silver surface, used in most headlamps. If a lamp was d without a reflector the light which ves the lamp filament would be thrown every direction per fig. 70. When a rector is used the light from the lamp filant is concentrated all in one direction, per fig. 71.



A ray of light is the light which falls on any one point of surface of reflector and is sent off from that point.

A beam is the toal mass of light rays leaving the opening in reflector.

One of the fundamental laws of light is, at the angle at which light leaves a surace is the same as the angle at which it rikes the surface. By referring to figs. 22, 3, 24, note angle which is made by the ays of light leaving the surface of the eflector at H, M, and N, is the same as he angle made by the ray of light striking he reflector at the same point. The angles t which the rays strike the reflector are alled "angles of incidence" and those leavng the reflector are called "angles of relection."

X—Focus Point O—Light Source

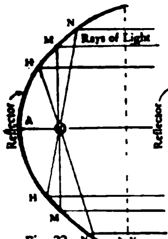


Fig. 22. Straight Beam

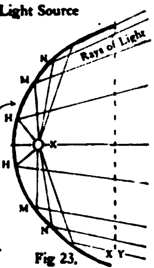


Fig 23. Spreading Beam

Fig. 22 shows distribution of light leaving opening of reflector when lamp filament O is at focal point X of reflector. The rays which start from point X, and strike reflector at H, M and N, must be reflected parallel to each other to make reflecting angles equal the striking angles. This gives a cylindrical or **straight beam.** The beam is theoretically the same size (XY fig. 22) throughout its entire length. A straight beam gives a very narrow streak of light down the center of the road like a spot light; but no light to the side of the road.

Fig. 23 shows the form of beam leaving the reflector when the filament O, is back of the focal point X. The rays spread or diverge from one another and form a **spreading beam,** with its narrowest point at opening of reflector, XY. Note that the light rays which leave the headlamp at a **rising angle** are those which come from the **upper half of the reflector.**

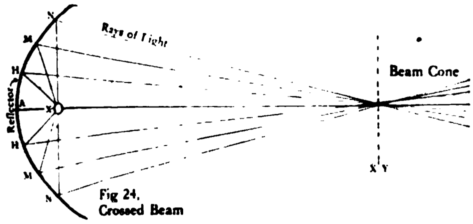


Fig 24. Crossed Beam

Fig. 24 shows the effect of bringing the filament O, ahead of the focal point X. This forms what we call a **crossed beam.** Note that the light rays which leave the headlamp at **rising angle** are those which come from the **lower half of reflector.**

Anti Glare Devices.

In most states, laws are being enforced to prevent glare. The light which produces glare is that part which leaves the headlamp at a **rising angle** and so never hits the road, but does hit the eyes of approaching drivers or pedestrians. These rays may come from either the top or bottom of reflector, depending upon the position of the lamp in the reflector.

Methods For Reducing Glare.

(1) **By using a very low candle power lamp; dimming the headlamps;** using whiting, semi-transparent paint or colored glass. Low candle power lamps reduce the brilliancy and colored glass or paint absorb part of the light and reduce the lighting effect desired and are unsatisfactory.

(2) By tipping the reflector forward enough to bring the upper edge of beam below the average eye level (*42 inches is the usual legal limit.) The distance to which the road will be lighted is very much shortened.

(3) **By diffusing the light by means of ground glass, office partition glass or specially designed "diffusing" lens,** having its surface covered by a large number of small lens or pyramids. With diffusing lenses there is a tendency to glare if the candle power of lamp is sufficient to light the road, as the light is thrown in all directions.

(4) **By using "deflecting lenses which bend or deflect that part of beam which leaves the headlamp at a rising angle** and direct this part of the beam back to the road level. Devices of this kind have the advantage of being able to limit the glare without cutting down the distance to which the light will be thrown on the road.

Some of the deflecting lenses which are constructed so as to affect all of the light leaving the headlamp, make it hit the road nearer to the car than it would with clear glass, and are not desirable.

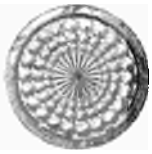


Fig. 65.

Fig. 66.

Fig. 65 is an example of a diffusing type lens. Both sides of glass are covered with small lenses. Adjust for a straight beam for best results.

Fig. 66 is a deflecting type lens. The horizontal prisms throw light on center of road and cylinders on inside, spread toward side of road. Hood at top intended to cut off any stray rays of light which might leave the headlamps at a rising angle. Adjust for a straight beam.

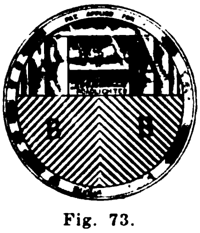


Fig. 73.

Fig. 73 is a deflecting type lens explained on page 435.

---

*The most common "glare height" regulation in regard to headlamps is that at a point 75 feet or more ahead of the car, the concentrated beam from the headlamp shall not rise more than 42 inches above the road level, when the car is standing on a level. In the latest headlamp regulations, the height has been raised to 60 inches from the road surface, and the intensity of the light is limited to a maximum of 800 candle power above this point.

Car and Model	HEAD LAMPS		SIDE LAMPS		TAIL LAMP		DASH LAMP		Fuses Amp.	Socket	Wiring System	Type of Dimmer.
	Volt.	Cp.	Volt.	Cp.	Volt.	Cp.	Volt.	Cp.				
Abbott-Detroit	6-8	15	6-8	4H	6-8	2	6-8	2	...	E.S.	S	...
Allen.......HI	6-8	18	6-8	4	6-8	2	6-8	2	15	E.S.	S	D. Bulb
American.....B	6-8	15	6-8	4H	3-4	2	3-4	2	20	E.S.	S	...
Anderson.....28	6-8	21	6-8	12H	6-8	4	6-8	4	...	E.S.	S	Warner lens
Apperson	6-8	18	...	...	6-8	2	6-8	2	10	E.D.	D	Resist
Auburn 39 B	6-8	15	6-8	4	6-8	2	6-8	2	25	E.S.	S	...
Auburn 44	6-8	18	6-8	12	6-8	2	6-8	2	...	E.S.	S	...
Austin	6-8	24	6-8	4H	6-8	4	...	...	...	E.S.	S	...
Bell.........18	6-8	18	6-8	4H	6-8	2	6-8	2	15	E.S.	S	...
Biddle.......H	6-8	21	6-8	4H	6-8	2	6-8	2	10	E.S.	S	...
Brewster	12-16	40	12-16	4H	6-8	2	6-8	2	10	E. S.	S	...
Briscoe	6-8	21	...	...	6-8	2	6-8	2	20	E.S.	S	Resist
Bour Davis	6-8	15	...	...	6-8	2	6-8	2	...	E.S.	...	...
Buick	6-8	15	6-8	4H	6-8	2	6-8	2	C.B.	E.S.	S	...
Cadillac.....57	6-8	18	6-8	8	3-4	2	3-4	2	C.B.	E.S.	S	Hdlamps
Case........U	6-8	18	6-8	4H	6-8	2	6-8	2	20	E.S.	S	...
Chalmers...6-30	6-8	15	6-8	4H	6-8	2	6-8	2	30 15	E.S.	S	...
Chandler	6-8	18	6-8	4H	6-8	2	6-8	2	20	E.S.	S	...
Chevrolet..4-90	6-8	12	...	...	6-8	2	6-8	2	20	E.D.	S	...
Chevrolet...FA	6-8	15	...	...	6-8	2	6-8	2	20	E.D.	S	...
Chevrolet....D	6-8	15	6-8	4H	6-8	2	6-8	2	20	E.S.	S	...
Cole.......870	6-8	21	...	...	6-8	4	6-8	6	...	E.S.	S	...
Columbia..C&D	6-8	15	6-8	4	6-8	2	6-8	2	None	E.S.	S	...
Commonwealth	6-8	15	6-8	4H	6-8	4	6-8	2	...	E.S.	S	...
Crawford..6-40	6-8	15	...	...	6-8	4	6-8	2	15	E.S.	S	...
Crow-Elkhart	6-8	15	6-8	4H	6-8	2	6-8	2	10	E.D.	S	Series
Cunningham..V	6-8	15	6-8	4	6-8	4	6-8	4	15	E.S.	S	Warner lens
Daniels......B	6-8	18	6-8	4H	6-8	2	6-8	2	15	E.S.	S	Warner lens
Davis	6-8	15	...	...	6-8	4	6-8	4	...	E.D.	S	Warner lens
Dixie Flyer	6-8	15	...	...	3-4	2	3-4	2	10	E.D.	D	Resist
Doble-Detroit	12-16	22	...	...	6-8	2	6-8	2	None	E.D.	S	...
Dodge Brothers	12-16	15	...	...	12-16	2	12-16	2	...	E.S.	S	Resist
Dorris.....6-80	6-8	15	6-8	4H	6-8	2	6-8	2	15	E.S.	S	...
Dort........11	6-8	15	...	...	6-8	4	6-8	2	10	E.S.	S	Resist
Elgin........A	6-8	21	6-8	4H	6-8	2	6-8	2	20	E.S.	S	...
Elcar	6-8	15	6-8	4H	6-8	2	6-8	2	15	E.S.	S	...
Empire	6-8	15	6-8	4H	3-4	2	3-4	2	20	E.S.	S	...
Fiat.......E-17	6-8	15	6-8	4H	6-8	2	6-8	4	...	E.S.	...	Warner lens
Ford.........T	6-8	...	...	...	...	...	...	...	...	E.D.	...	...
Franklin......9	12-16	21	12-16	4H	6-8	2	6-8 12-16	2 2	10	E.D.	...	...
F. R. P....45-B	12-16	25	12-16	8	12-16	3	12-16	3	6-3	E.S.	S	...
Glide.....6-40	6-8	15	6-8	4H	6-8	2	6-8	2	15	E.S.	S	...
Grant.......G	6-8	15	6-8	4H	6-8	2	6-8	2	20	...	S	Resist
Halladay	6-8	15	6-8	4H	6-8	4	6-8	2	...	E.S.	S	...
Harroun....A-1	6	15	...	...	3	2	3	2	15	E.S.	S	Resist
Haynes	6-8	15	6-8	12H	6-8	2	6-8	2	5	E.D.	D	Series
Hollier	6-8	15	...	...	6-8	2	6-8	2	20	E.S.	S	Series
Hudson	6-8	15	...	...	3-4	2	3-4	2	...	E.S.	S	Resist
Hupmobile. R	6-8	15	6-8	2	6-8	2	6-8	2	15	E.S.	S	Resist
Inter-State...T	6-8	15	...	...	6-8	2	6-8	2	10	E.D.	S	Resist
Jackson....349	6-8	15	...	...	6-8	2	6-8	2	20	E.D.	S	...
Jones..27ABC	6-8	21	6-8	2	6-8	2	6-8	2	15	E.S.	S	Resist
Jordan. 5-60	6-8	18	6-8	4H	6-8	3	6-8	3	20	E.S.	S	...
King.........F	6-8	18	6-8	4H	6-8	4	6-8	2	10	E.S.	S	Series
Kissel	6-8	18	...	...	6-8	2	6-8	2	20	E.D.	S	Series
Kline.....6-38	6-8	15	6-8	4	6-8	2	6-8	2	15	E.S.	S	...

Car and Model	HEAD LAMPS		SIDE LAMPS		TAIL LAMP		DASH LAMP	
	Volt.	Cp.	Volt.	Cp.	Volt.	Cp.	Volt.	Cp.
Lexington. 6R	7	30 32	...	...	6	2	6	4
	7	6	...	...				
Liberty.....10B	6-8	15	...	H	6-8	2	6-8	2
Locomobile	6-8	21	6-8	6	6-8	4	6-8	4
McFarlan.....X	6-8	24	6-8	12H	6-8	2	6-8	2
Madison	6-8	15	6-8	6H	6-8	4	6-8	4
Maibohm A	12	18	12	4	6	2	6	2
B	6-8	18	6-8	4	6-8	2	3-4	2
Marmon......34	6-8	24	6-8	8H	6-8	4	6-8	6
Maxwell.....25	12-16	24	12-16	...	12-16	2	12-16	2
Mercer...Ser.4	6-8	21	6-8	4	6-8	4	6-8	4
Metz.........25	6-8	15	6-8	4H	6-8	2	6-8	2
Mitchell.. D-40	6-8	15	...	...	6-8	2	6-8	2
Moline-Knight	6-8	15	6-8	6H	6-8	2	6-8	4
Monroe	6-8	15	6-8	2H	6-8	2	6-8	2
Moon	6-8	15	...	...	6-8	2	6-8	4
Murray 70T	6-8	18	6-8	4H	6-8	2	6-8	4
Nash	6-8	14	6-8	4H	6-8	2	6-8	2
National	6-8	18	6-8	4H	6-8	2	6-8	2
Nelson	12-16	30	12-16	6H	12-16	2	12-16	2
Oakland 31-B	6-8	15	...	...	6-8	2	6-8	2
Oldsmobile. 37	6-8	15	6-8	4H	6-8	2	6-8	2
Olympian	6-8	15			6-8	2	6-8	2
Overland	6-8	16	...	...	3-4	2	3-4	2
Owen O-36	28	21	28	4H	28	2	28	2
M-25	14	21	14	4H	14	2	14	2
W-42	28	21	28	4H	28	2	28	2
Paige	6-8	15	6-8	4H	6-8	2	6-8	2
Paterson...6-45	6-8	12	6-8	8H	3-4	2	3-4	
Packard	6-8	24	6-8	6	6-8	2	6-8	4
Pan-American	6-8	15	...	...	6-8	2	6-8	2
Peerless....56	6-8	15	6-8	4	6-8	2	6-8	2
Pierce-Arrow	6-8	21	6-8	4	6-8	4	6-8	4
Pilot......6-45	6-8	15	...	...	6-8	2	6-8	2
Premier 6-C	6-8	21	6-8	4	6-8	2	6-8	2
Regal........J	6-8	21	...	...	6-8	4	6-8	2
Reo.........M	6-8	15	...	...	3-4	2	3-4	2
Reo..........T	6-8	15	...	...	3-4	2	3-4	2
Saxon	6-8	12	...	...	6-8	2	6-8	2
Scripps-Booth	6-8	15	6-8	4H	6-8	2	6-8	2
Simplex......V	12-16	40	12-16	4H	6-8	2	6-8	2
Singer.......17	6-8	32	...	...	6-8	2	6-8	2
Standard.....G	6-8	18	6-8	4	6-8	2	6-8	2
Stanley Steamer	6-8	18	6-8	4H	6-8	2	6-8	2
Stearns SK8	12-16	24	12-16	4H	12-16	2	12-16	2
SKL-4	12-16	18	12-16	4H	12-16	2	12-16	2
Stephens	6-8	21	6-8	4	6-8	2	6-8	2
Studebaker SH, EH, EG	6-8	12	...	...	6-8	2	6-8	2
Stutz........S	6-8	18	6-8	4H	6-8	2	6-8	4
Templar	6-8	18	6-8	4	6-8	2	6-8	2
Velie. 38-39	6-8	15	6-8	4	3-4	2	3-4	2
Westcott. S-18	6-8	15	6-8	4H	3-4	2	3-4	2
White	12-16	25	12-16	4H	12-16	2	12-16	4
Willys-Knight	6-8	18	...	...	3-4	2	3-4	2
Winton...33-48	6-8	21	6-8	12	6-8	4	6-8	2
Woods.......54	60	25	30	8H	30	10	30	10

ABBREVIATIONS:—C.B.—Circuit breaker (see page 429). D.—Double wiring system.
double contact (see page 433). E.S.—Ediswan single contact. H.—Small bulbs in head-lamps
ing. Resist.—Resistance. S.—Single wiring system. Series—Series connection. (Motor Wor
Above are 1918 c. p. bulbs. As bulbs have now been standardized as below, it will be necess
nearest c. p.—as per table below.

MAZDA LAMPS

Illustrations one half actual size.

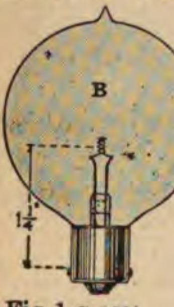


Fig. 1 G-16½

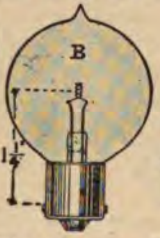


Fig. 2 G-12

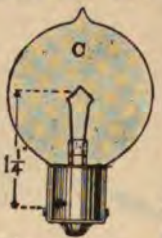


Fig. 3 G-12

CANDLE POWER AND AMPERE TABL

Location	Class	Volts	CP	Amperes
Rear	B	6-8	2	.42
*Side	"	"	5	.84
Head	"	"	17	2.3
"	"	"	24	3.3
Ford	"	9	21	2.0
Rear	"	12-16	3	.38
*Side	"	"	6	.42
Head	"	"	16	1.00
"	"	"	16	1.30
"	C	6-8	25	2.5
"	"	"	32	4.0
"	"	12-16	30	1.5
Ford	"	9	27	2.0

Rear and speedometer bulb are 2 c. p. and usually
case the voltage would be 3-4 volts, .84 amp. each on 6-8 volt
each of 3 c. p. .42 amp. or 12-16 volt circuit. Dome,

Mazda B, 6 to 8 volt, made in 2, 5,
Mazda C, 6 to 8 volt, made in 20, 32
Mazda B, 12 to 16 volt, made in 3, 6
Mazda C, 12 to 16 volt, made in 30
Mazda B for Ford, 9 volt, are made
Mazda C for Ford, 9 volt, are made

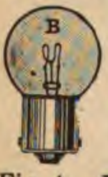


Fig. 4 G- 8

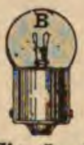


Fig. 5 G- 6

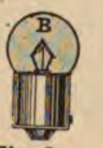


Fig. 6 G- 6

Two lamps are used in "series," with double contact b
the Ford.

G-6, G-8, G-12, G-16½: G, designates that bulb is round
6, 8, 12 or 16½ means that many **eighths** of an inch. As
of an inch, equals 2¹⁄₁₆ inches di. of bulb. **S,** single conta
contact base.

Proper voltage and base of lamps for Ford "Special" ligh
Genemotor, 12-16 v. D. C. base; Gray-Davis, 6-8 v. S. C.;
Westinghouse, 12-16 v. S. C. (D. C. and S. C. means dou
contact base.)

CHART NO. 197—Lamp Bulbs; Voltage and Candle Power Used on 1918 Cars and of Bulbs for 1919. See also pages 543 to 546.

Chart 196 omitted (error in numbering).

ideal roadlight would be one which would **the road** from fence to fence for at least **feet ahead** of the car. The edge of the road **d be so** brightly "spot-lighted" that it could **een and followed in spite of the glare from pproaching** car. One make of lens designed **eet these** conditions is shown in fig. 78.

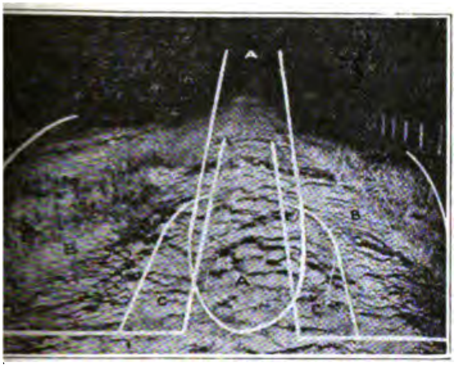


Fig. 72.

he diagonal prisms (fig. 78) on lower half **reflector** bend the light which would otherwise **se glare**, to light the sides of the road at BB. **e vertical** prisms on upper half concentrate **distance** light on the road shown at A. The **ot-light** effect is shown at CC, fig. 72. The **justment** is for a wide crossed beam.

Adjustment and Focus For Different Lenses.

When a "diffusing" type of lens is used it akes no difference whether you have a crossed am, spreading beam or straight beam, except at where a straight beam is used there will be s diffusion, and consequently a stronger light ead of the car.

When a "deflecting" type of lens is used it is bsolutely necessary to know whether it is tended for use with a spreading, crossed or raight beam before the focus can be made to sure satisfactory results, therefore manufacrer's instructions should be followed carefully.

If that part of the deflecting lens which is designed to bend the "glare rays" down towards he road is located in the **upper half** of the lens, "spreading beam" must be used. If located n the **lower half**, a "crossed beam" must be sed.

If the device is made of prisms having a uniorm angle on both upper and lower halves of the evice, a "straight beam" must be used.

Checking Lamp Adjustment.

To find out whether the lamp is set for a "spread" or "crossed beam" pass a screen such as a piece of board or paper, down in front of he headlamp. If the shadow caused by the screen moves up as the screen moves down, the filament of the lamp is in front of the focal point (fig. 10) and you have a "crossed beam." If the shadow moves down with the screen, the lamp is set for a "spreading beam."

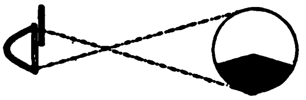


Fig. 10.

Another method to test if light is a crossed beam or spreading beam; let the light from the headlight shine on a wall or screen 10 or 15 feet ahead of the lamp. Then move the lamp bulb back in the reflector.

If the spot on the wall grows **larger** as the lamp bulb is moved toward the back of the reflector, the lamp is adjusted for a **spreading beam** and the filament is **back** of the focal point.

If the spot on the wall grows **smaller** as the lamp is moved back towards the reflecter, the adjustment is for a **crossed beam**, and the filament is **ahead** of the focal point.

If the filament is moved from as far back in the reflector as it will go, to a point as far ahead as it will go, you will find that the spot of light will first grow smaller and then grow larger, as the filament passes the focal point. The point where the spot is smallest is the point where the filament is practically at the focal point X, and the adjustment is for a **straight beam**.

These tests are of course, made with plain lens.

Focusing Headlamps with Plain Lens.

One plan would be to take car out on a level road at night and set the headlamps so that both of them point straight down the road. Then adjust or focus the position of the lamp in the reflector until the light covers a width of about 25 feet on the road at a point 150 feet ahead of the car. The headlamps should be tipped forward slightly, so as to bring the brightest part of the light on the road at a point about 150 feet ahead of the car.

If it is necessary to make the adjustment on the headlamps during the daytime in a garage, or some place of that kind, set the car so that the light will shine squarely on a wall or screen 20 feet ahead of the car, fig. 18. Adjust or focus each headlamp separately until the spot thrown by each lamp on the wall is about 3 feet in diameter.

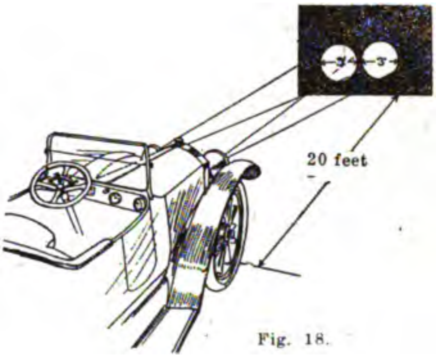


Fig. 18.

With both lamps throwing light on the wall, adjust the headlamps themselves so that the distance between the centers of the two spots on the wall will be the same as the distance between the centers of the headlamps. Tip the headlamps forward so that the centers of the two spots on the wall will be about 4 inches lower than the centers of the openings in the headlamps. This will bring the upper edge of the beam as low as practical without too much loss of distance.

Note. The above adjustment should only be used with plain glass in the headlamps, or with diffusing lenses, and may not be correct where deflecting lenses are to be used.

To Clean Reflector and Lens.

Do not forget that dust or dirt on the reflector or on the glass lens may cut down the light on the road by more than half.

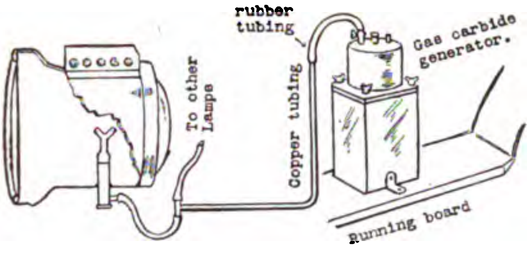
To clean reflector, use a very soft, clean cloth without using pressure and in a circular motion. Never rub a reflector with a cloth or chamois skin which is covered with dust or grit. It will scratch the reflector and ruin it for service.

If a reflector becomes tarnished or scratched, take it to a silver plater and have it buffed. It cannot be properly polished in any other way.

To Clean the Glass Lens.

Absorbent cotton, dipped in alcohol and lightly rubbed in a circular motion over the surface will be found efficient.

Assisted by Mr. Frederick H. Ford. **Address of Lens manufacturers:** The Roadlighter Lens, fig. 72 and 73, are manufactured by C. A. Shaler Co., Waupun, Wiscn.; The Warner Lens Co., 914 Mich. Ave., Chicago; Macbeth. by Macbeth-Evans Glass Co., Pittsburg; Legalite, by The Legalite Corpn., Boston, Mass.; Sun Ray, by Prismolite Co., Columbus, Ohio; Conaphore, by Edw. A. Cassidy Co., Madison Ave. and 40th St., New York.



Gas Lighting.

Fig. 1—Showing how small 1-8 inch copp tubing and rubber tubing connects fr generator to lamps. Note the rubber tubin connected from the copper tubing to th lamp drops in a curve. This will place th rubber tubing at the lowest point. Gas co denses and turns to water and the wa clogs the pipes and gas tips. If this rubb tubing is disconnected occasionally the co densed water will drain out.

It is always necessary that the line b leads from the gas generator to the lamps b on as much of an incline as possible. I fact, a d aincock could be placed at the lowe point to advantage. The pipes to each lam should be independent if possible.

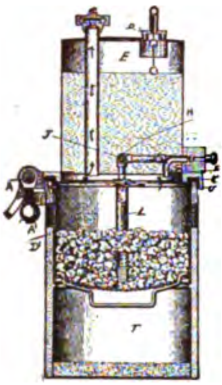


Fig 11—The Solar drip type; gas generator. The used up carbide shakes through the perforations into the base (T) of the generator. The water tank forms the top part of the generator.

Fig. 11—Explanation of the drip type of carbide generator: The tank (E being filled with water at (D) the water saturates the cotton wick (H) in th tube (J) and the valve (F) being turned ON it drops into the screen tube (L passing out of the holes at the bottom, coming in contact with the carbide, form gas which passes out at top of generator through pipe (G). The unused carbi held in the cage is separated by the screen in the bottom and the dust or us carbide falls to the bottom (T) perfectly dry. Consequently the charge is always fresh while it lasts and ready to light or extinguish, and cleaning simply means emptying the dry dust at the bottom and refilling the cage with carbide and the tank with water. To shut off the light turn the valve (F) off: (F) being a two-way valve on the side (not lettered) the gas then contained in the generator passes out of the two-way valve into the ir thus insuring perfect safety.

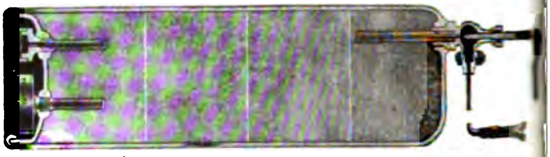
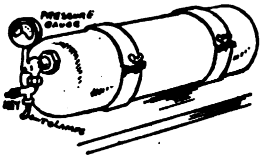


Fig 14.—Sectional View of the Gas Tank.



Figs. 14 and 14A. Th Pressure Gas Storage Ta usually placed on the run**ning board of car. S** text. for explanation of co**struction and use.**

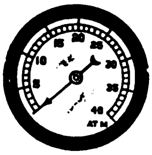


Fig. 16 — Gauge reading in atmospheres.*

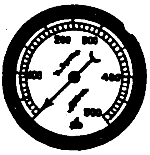


Fig. – Gauge reading in pounds.

Fig. 15—Combin ation gauge read ing in pounds an atmosphere.

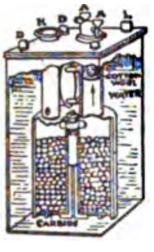


Fig 13-The Automatic Type of Gas Generator.

Fig. 13—Simple form of Diving Bell generator for Acetylene gas; called the automatic type.

When the supply to lamps is shut off the pressure of gas in the inner chamber drives the water up from the calcium carbide.

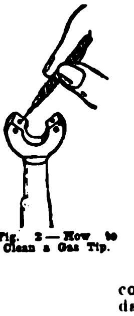


Fig. 2—How to Clean a Gas Tip.

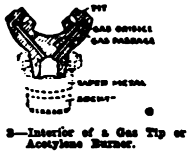


Fig. 3—Interior of a Gas Tip or Acetylene Burner.

Tips are generally made of lava. Two small holes are in each end, only one of these being discernable to the eye. The hole, however, which becomes clogged is the small hole inside the large one.

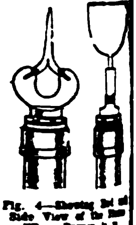
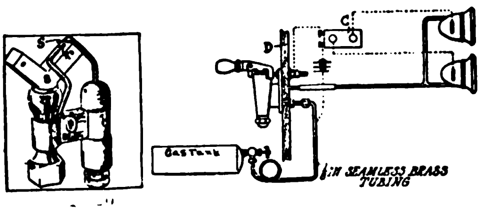


Fig. 4—Showing End an Side View of the Bur When Burner is i Good Order.



Lighting the gas by an electric spark: This system consists of a special valve and switch placed on the dash-board (D). a high tension coil (C), and a special gas lighting attachment shown at the left in cut.

The connections are as follows. The gas tank is piped to the valve and connected to a union under it. After gas passes through valve it is then carried to the lamps. Wire runs from switch to coil and from there through primary winding to battery. Through battery to ground.

An attachment (B1) is placed on each gas tip to be lighted. When lever is pressed down this opens the gas and also makes a temporary electric contact and spark jumps across points S, and lights the gas. An ignition battery or dry cells will do this work.

See also page 726 for another principle.

CHART NO. 198—Gas Lighting; Independent Gas Generator and the Gas Tank.

***An atmosphere equals 14.7 lbs. at sea level.**

Charts 199 and 200 omitted (error in numbering)

Opening Electric Headlamps.

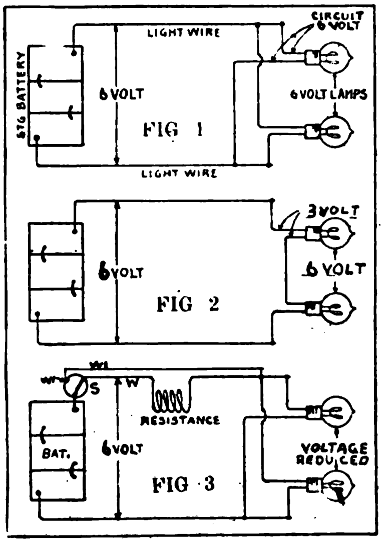
The "door" to the headlamp may be fastened on in one of several ways. There may be a hinge at the top and a screw clamp at the bottom or the hinge may be at one side and the clamp at the other. If no hinge shows, and the "door" overlaps the shell of the headlamp, the "door" can probably be removed by **pressing it in, and at the same time turning it to the left.**

In some headlamps, the glass is held in place by a retaining spring, which slips in between the headlamp shell and the glass.

In other headlamps, the rim which holds the glass is held up against the shell by a band which fits over shoulders on both rim and shell, and is drawn up by a screw at the bottom of the headlamp.

Dimming The Headlight Lamps.

These methods of dimming the lights were formerly used when car was standing. Most cars are now equipped with small lamps in upper part of headlamp, which are only 5 c. p., therefore the methods described are now seldom used.



There are two general principles for dimming lights; by "resistance" (which causes loss of current) cut into the circuit (fig. 3), and by **throwing** lights in "series" connections (fig. 2).

Fig. 1, we will assume all light circuits are 6 volts in the three illustrations. In fig. 1, the two lights are connected in parallel—the terminals of each light connect with the six volt circuit.

Fig. 2; To dim by a "series" connection—the switch and wiring is arranged so that the parallel connections as in fig. 1, are cut out, and lights are connected so that current from the two light wires must flow through both lamps—"serially" or generally termed, connected in "series." If each lamp is 6 volts and there is only a 6 volt supply—then each lamp will get but 3 volts or half its voltage; hence will burn half as bright.

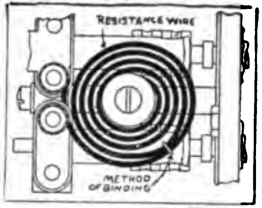


Fig. 4.

Fig. 4. Method of increasing brilliancy of lamps, when a "resistance" type of dimmer is used.

Note, part of the resistance wire is short circuited by binding as shown.

When German silver wire or some other form of resistance is used for dimming lights the principle is to cut this resistance into the line as shown in (fig. 3). The lights will then be dimmed according to the amount or length of wire placed into the circuit.

A switch (S) can be arranged so that by placing point of switch blade on WI, fig. 3, the resistance is cut out. When connected with wire W—it is cut in.

To vary the intensity of the headlights when dimmer is in circuit (Delco system, page 891), is merely a matter of shortening the path of the flow of current (the dimmer "resistance" wire) —which can be done by tieing one coil together, which will make considerable difference, fig. 4.

To do this; it is necessary to remove the switch. Remove the four bolts passing through housing at back of switch. The housing will then come apart. Remove No. 1 wire which connects with generator, before dismantling switch. Otherwise a short circuit will result.

A "Spot" Light.

Is a type of lamp, which can be placed on the wind-shield, and turned in any direction by hand. It is also well adapted for army use.

Where a great deal of night driving is done or a cross-country trip made, **a spot light is of great** convenience. It is fastened close to the driver's hand and can be directed at any spot desired.

Adjustment is for a "straight-beam" with filament exactly at focus point, see fig. 22, page 433.

Spot lights are prohibited in some states, and in others the law requires that the light be thrown on the ground, not more than 60, 75 or 100 feet ahead of car and must not be directed in the faces of persons approaching.

Elecric bulb is usually nitrogen type 20 or 32 c. p.

*Gas Lighting—see page 436.

There are two types of gas or carbide generators in use: the drip type and the automatic type.

In the "drip" principle of generation, the water is **usually arranged to drip directly** on the carbide, and the amount of gas formed is regulated by a tap which allows more or less water to come in contact with carbide. (Fig. 11.)

A modification of this system, allows the water to drip down a perforated metal tube, surrounded with carbide, and thus the water gradually soaks through the carbide.

All generators are now made specially with a view to ease of detachment, refilling or charging, and cleaning; this latter is specially important, as any neglect to clean out the lime residue from the container immediately after a period of use renders cleaning a matter of considerable difficulty.

Another important detail in working a generator is always to obtain the best quality of carbide, keep it in a thoroughly dry place, and tightly sealed up to prevent deterioration.

Fig. 13. The automatic type of generator; in some respects, is simpler and gives a better regulation of the gas, but it does not seem to be always reliable.

In brief, the working is as follows: The carbide is contained in a bell or chamber, with perforated sides and bottom, to admit water freely. This bell has a suitable outlet for the gas.

It is supported inside an outer vessel or tank, to hold the water. Immediately the water comes in contact with the carbide gas is generated and, if the supply tap is open this gas will pass on to the lamps. Should the tap be closed, the pressure exerted by the gas then acts inside the bell, and drives the water away from the carbide.

Should the generation of gas still continue for some time it will force its way through the water and escape into the atmosphere, through a small vent hole, so that no dangerous pressure can develop within the generator.

It will be seen that an automatic regulation of the gas is thereby obtained, because immediately more is being generated than can be used; the water is driven away from the carbide, but as soon as there is a demand for more gas the pressure inside the bell falls and water re-enters.

The gas outlet pipe and cotton wool or horsehair filter, whence the gas reaches the top or, to which the tubes are connected to the lamps is shown at (AA).

---

*Gas lighting is now seldom used, but is explained for the benefit of the reader

A gas bag is provided on the gas outlet pipe inside the generator to steady the pressure.

The carbide container lifts right out of the tank by unscrewing the nuts (D D).

The tank is filled up from the aperture (K) in the plug of which is a small vent acting as a safety valve. In this, as in other forms, the gas can be turned on and off any number of times till the carbide is all used up.

*Gas Burners;—Also called Gas Tips.

The gas burner is made up in various styles, and consumes from .25 to 1.5 cubic feet of gas per hour. By referring to figs. 3 and 4, chart 198, the reader will observe the construction.

If acetylene gas was used with an ordinary jet, it would have a yellow tint, but the oxygen drawn into the tip through the large hole raises the temperature of the flame to a point where a white blaze is obtained, therefore it is necessary that the smaller hole in the burner be kept clean.

If the flame is yellow and dim the above is probably the cause, or the pipe line needs blowing out, or the generator needs cleaning.

If the independent generator is used, it is important that all parts be perfectly clean and fresh carbide added daily, using quantity required.

Lighting the Gas.

The usual method for lighting the gas is to turn on the gas at the generator or tank and light the gas at the burners with a match.

The modern method is to turn on and light the gas from the seat. This is accomplished by a valve and electric spark. (see fig. 20, page 436.)

Non-Freezing Solution for Gas Generators.

Use plain alcohol in the proportion here given. Alcohol is a fuel, but not explosive. It will, therefore, probably give a slightly stronger gas than water, and for this reason less will be required. Do not use glycerine, as this is an explosive.

Percentage of alcohol to water: At 18 degrees, 10 per cent; at 5 degrees, 20 per cent; at —2 degrees, 25 per cent; at —9 degrees, 30 per cent; at —15 degrees, 35 per cent; at —24 degrees, 40 per cent.**

Carbide—Used in the Generators.

The chemical formula for Acetylene is C H (i. e., a compound of carbon and hydrogen). It has a characteristic pungent odor—which at once gives evidence of any leakage—and is a poison if inhaled in any quantity.

Approximately one pound of good quality calcium carbide, will generate six cubic feet of acetylene gas. It can readily be liquified or compressed but in this state it is highly explosive, and its use finds no favor in this country. What is known as dissolved acetylene however, is safe.

The gas in a moist or impure state attacks copper or brass, forming acetylene of copper, which is exceeding explosive, so much so that it will go off by slight friction or a blow. **This** accounts for the small explosions that are sometimes experienced when cleaning a generator.

†The Pressure Gas Storage Tank.

This tank is charged at the factory. When the tank is exhausted it is taken to the local agent and exchanged for a fully charged tank.

The gas used in the tank is acetylene gas, made from carbide—the same kind of gas used in a generator. Figs. 14 and 14A, chart 198, illustrate the Prestolite gas tank. The amount of gas in the tank is indicated by the pressure gauge. In this way the motorist can tell the quantity of gas in the tank. A key opens the valve which allows only a low pressure of gas to feed the lamps.

The piping of the gas from the gas tank to the lamps is just the same as used with an independent generator.

The Prestolite gas tank is made in three styles: Style E which weighs 23 lbs.; style B, 30 lbs., and style A, 50 lbs.

The pressure inside the tank (E) is based on a pressure of 15 atmospheres or about 50 cubic feet of gas which will supply gas for 2, ½-foot burners for 50 hours.

The tank should be placed on the car so that it can be easily removed. The running board is a convenient place. Always place tank top side up.

Prestolite Gas Tank Pointers.

Prestolite gauges, how to read them; several styles of gauges are used, some register in atmospheres, some in pounds and some in both, (see figs. 16, 17, 18, chart 198). If you wish to determine the number of pounds of pressure in your tank, reading from a gauge showing only atmospheric pressure, multiply the number of atmospheres shown, by 14.7 which is the number of pounds to which one atmosphere is equal. The result will give you the number of pounds of pressure in your tank. All atmosphere gauges are marked "ATM."

Prestolite tanks are charged to a pressure of 225 pounds (equal to approximately fifteen atmospheres) at 65 degrees Fahrenheit. If the temperature of a tank be increased 10 to 20 degrees F. the pressure will be raised 25 to 50 pounds. If the temperature be lowered, the pressure will be reduced in about the same ratio. This accounts for the rapid fall in the gauge pressure when a tank is taken from a warm garage into the cold air of the street. Change in temperature does not affect either the quantity or the quality of the gas. Consequently when the outside temperature is 65 degrees F. a properly filled Prestolite tank will show a pressure of about 15 ATM (atmospheres) when using the atmospheric type of gauge, and 225 pounds when using the gauge reading in pounds, while the gauge showing both pounds and atmospheres will indicate a pressure of 221 pounds, or 15 ATM, with corresponding variations according to the outside settled temperature, despite the fact that the first two mentioned gauges show a capacity of 40 ATM and 500 pounds, respectively.

Where to look for leaks: Note: rub soap-suds along the pipe lines and over all joints and connections. Do not use a match, any sooner than you would use one to hunt for a gas leak in your cellar.

(1) Union where attached to tank; (2) rubber hose connecting union with brass piping of car; (3) joints where rubber hose connects with union and with piping of car; (4) joints, T's or crosses where piping branches; (5) where rubber hose connects piping with lamps; (6) part of lamp to which burners are attached; (7) any point on piping where there is a liability of chafing.

Sizes and capacities of Prestolite tanks: "A"—22 inches long, 7¼ inches in diameter; contains 70 cubic feet of gas.

Using two ½-ft. burners, 70 hours lighting
Using two ⅝-ft. burners, 56 hours lighting
Using two ¾-ft. burners, 46 hours lighting

"B"—20 inches long, 6 inches in diameter; contains 40 cubic feet of gas.

Using two ½-ft. burners, 40 hours lighting
Using two ⅝-ft. burners, 32 hours lighting
Using two ¾-ft. burners, 26 hours lighting

"E"—16 inches long, 6 inches in diameter; contains 30 cubic feet of gas.

Using two ¼-ft. burners, 60 hours lighting
Using two ½-ft. burners, 30 hours lighting

Oil Lighting.

Inasmuch as electricity for lighting is now the adopted standard and is almost universally used, it is hardly worth while to deal with the kerosene oil lamp. The oil lamp when used in place of electric lights, is generally placed tail or rear lamp, to illuminate the license number and as required by law for protection of the fire department.

The brilliancy of oil lights can be improved by using a hard wick and placing cotton in the bowl of lamp. Then use gasoline or half gasoline and light cylinder oil instead of kerosene.

---

*Gas burners are also called gas tips—the average gas tips consume one-half foot of gas per hour. Gas tips are made in standard sizes as follows: ¼ foot, ½ foot, ¾ foot and 1 foot.

*The dash in front of the figures are "minus" signs or below zero. †See page 718 for further details of a gas tank.

Glossary to the Storage Battery Instruction.

This page is provided for reference, in case reader is not familiar with words or terms used.

Acid. As used in this book refers to sulphuric acid (H_2SO_4) the active component of the electrolyte.

Active material. The active portion of the battery plates; peroxide of lead on the positives and spongy metallic lead on the negatives.

Alternating current. Electric current which does not flow in one direction only (like direct current), but rapidly reverses its direction or "alternates" in polarity so that it will not charge a battery.

Ampere. The unit of measurement of the rate of flow of electric current.

Ampere hour. The unit of measurement of the quantity of electric current. Thus, 2 amperes flowing for ½ hour, equals 1 ampere hour.

Arc burning. Making a joint by means of electric current which melts together the metal of the parts to be joined.

Battery. Any number of complete cells assembled in one case.

Battery terminals. Devices attached to the positive post of one end cell and the negative of the other, by means of which the battery is connected to the car circuit.

Buckling. Warping or bending of the battery plates.

Burning strip. A convenient form of lead in strips, for filling up the joint in making burned connections.

Case. The containing box, which holds the battery cells.

Cell. The battery unit, consisting of an element complete with electrolyte in its jar with cover.

Cell connector. The metal link which connects the positive post of one cell to the negative post of the adjoining cell.

Charge. Passing direct current through a battery, in the direction opposite to that of discharge, in order to put back the energy used on discharge.

Charge rate. The proper rate of current to use in charging a battery from an outside source. It is expressed in amperes and varies for different sized cells.

Corrosion. The attack of metal parts by acid from the electrolyte; it is the result of lack of cleanliness.

Cover. The rubber cover which closes each individual cell; it is flanged for sealing compound, to insure an effective seal.

Discharge. The flow of electric current from a battery through a circuit. The opposite of "charge."

Electrolyte. The fluid in a battery cell, consisting of specially pure sulphuric acid, diluted with pure water.

Element. One positive group, and one negative group with separators, assembled together.

Filling plug. The plug which fits in and closes the orifice of the filling tube, in the cell cover.

Flooding. Overflowing through the filling tube. With the "exide" automatic filling tube, this can usually occur only, when a battery is charged with the filling plug out.

Freshening charge. A charge given to a battery which has been standing idle, to insure that it is in a fully charged condition.

Gassing. The bubbling of the electrolyte caused by the rising of gas set free toward the end of charge.

Generator system. An equipment including a generator, for automatically recharging the battery; in contradistinction to a straight storage system where the battery has to be removed to be recharged.

Gravity. A contraction of the term "specific gravity," which means the density, compared to water as a standard.

Grid. The metal framework of a plate, supporting the active material, and provided with a lug for conducting the current and for attachment to the strap.

Group. A set of plates, either positive or negative, joined to a strap. Groups do not include separators.

Hold-down clips. Brackets, for the attachment of bolts, for holding the battery securely in position on the car.

Hydrogen flame. A very hot and clean flame of hydrogen gas and compressed air, used for making burned connections.

Hydrogen generator. An apparatus for generating hydrogen gas for lead burning.

Hydrometer. An instrument, for finding the specific gravity of the electrolyte.

Hydrometer syringe. A glass barrel enclosing a hydrometer and provided with a rubber bulb, for drawing up electrolyte.

Jar. The hard rubber container, holding the element and electrolyte.

Lead burning. Making a joint, by melting together the metal of the parts to be joined.

Lug. The extension from the top frame of each plate connecting the plate to the strap.

Maximum gravity. The highest specific gravity which the electrolyte will reach by continued charging; indicating that no acid remains in the plates.

Oil of vitriol. Commercial name for concentrated sulphuric acid (1.885 specific gravity). This is never used in a battery and would quickly ruin it.

Plates. Metallic grids, supporting active material. They are alternately positive (brown) and negative (gray).

Polarity. Electrical condition. The positive terminal of a cell or battery, or the positive wire of a circuit, is said to have positive polarity; the negative; negative polarity.

Post. The portion of the strap extending through the cell cover, by means of which connection is made to the adjoining cell, or to the car circuit.

Rectifier. Apparatus for converting alternating current into direct current.

Resistance. Material (usually lamps or wire) of low conductivity, inserted in a circuit to retard the flow of current. By varying the resistance, the amount of current can be regulated.

Rubber sheets. Thin, perforated hard rubber sheets, used in combination with the wood separators in some types of batteries. They are placed between the grooved side of the wood separators, and the positive plate.

Sealing compound. The acid proof compound, used to seal the cover to the jar.

Sealing nut. The notched round nut, which screws on the post and clamps the cell cover.

Sediment. Active material which gradually falls from the plates, and accumulates in the space below the plates, provided for that purpose.

Separators. Sheets of grooved wood, specially treated, inserted between the positive and negative plates to keep them out of contact.

Short circuit. A metallic connection between the positive and negative plates within a cell. The plates may be in actual contact or material may lodge and bridge across. If the separators are in good condition, a short circuit is unlikely to occur.

Spacers. Wood strips, used in some types to separate the cells in the case, and divided to provide a space for the tie bolts.

Specific gravity. The density of the electrolyte compared to water as a standard. (see page 585 for sp. gr. of water). Often abbreviated as "gravity" or "sp. gr." or "S. G."

Starvation. The result of giving insufficient charge, in relation to the amount of discharge, resulting in poor service and injury to battery.

Strap. The leaden casting to which the plates of a group are joined.

Sulphated. The condition of plates having an abnormal amount of lead sulphate, caused by "starvation" or by allowing battery to remain discharged.

Tie bolts. Bolts which, in some types, extend through the battery case between the cells, and clamp the jars in position.

Top nut. The hexagon nut which, in batteries with bolted connections, screws on the post, and holds the connectors and sealing nut in place.

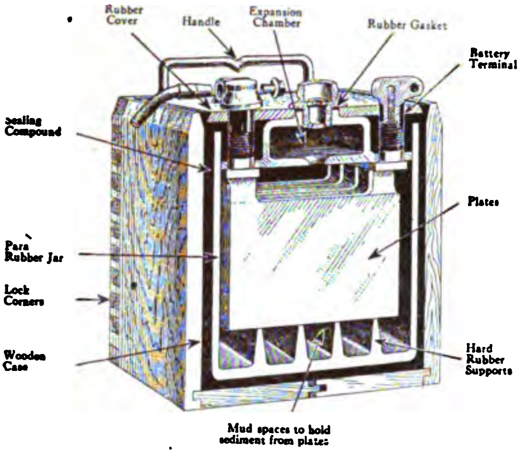


Fig. 1.—Sectional view showing location of the parts of a starting and lighting storage battery.

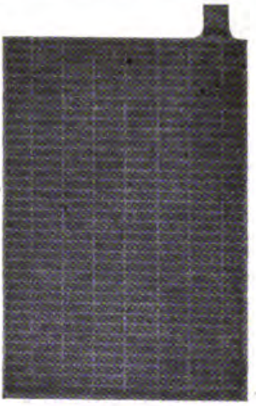


Fig. 2.—Positive plate. Faure pasted type. The color of the positive plate is dark chocolate color.

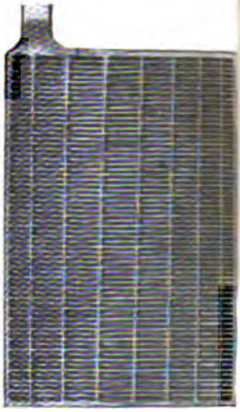


Fig. 3.—Negative plate. Faure pasted type. The color of the negative plate is gray. Note the plate is "gridded" so it will retain the paste.

The construction of a storage battery is explained in the text following. In this chart the parts of a storage battery are illustrated, also the two types of plates, the pasted plate, called **Faure** type, fig. 2, and the **Plante** type, fig. 4. The Faure type is the plate generally used.

There are more negative plates than positive plates, for instance, one type of a starting and lighting battery would have to each cell, 15 plates; 7 positive and 8 negative. The **size of the plates determine the amperage** output of battery.

***The voltage** of a storage battery is determined by the number of cells, each cell gives, on open circuit—from 2.1 to 2.2 volts when charged, no matter how many plates or the size of the plates. If there are 3 cells to a battery, then the voltage would be 6.6 volts.

On a discharge—a charged battery will give 2 volts per cell.

The relative size of the starting and lighting battery and the ignition battery is shown below.

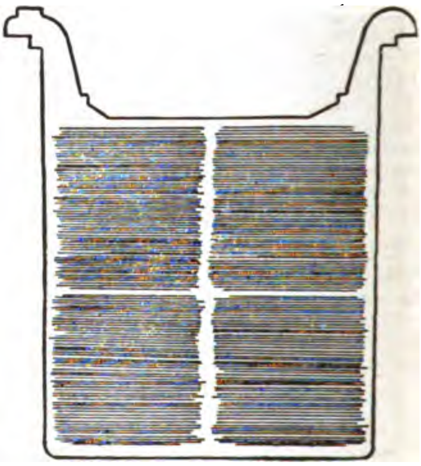


Fig. 4.—The Plante type of plate: this plate differs from the Faure or grid type as shown in figs. 2 and 3. On the Faure the lead plates are cast with grids or openings to take the paste. The Plante plate is more finely subdivided and has a spongy appearance (seldom used), see page 445.

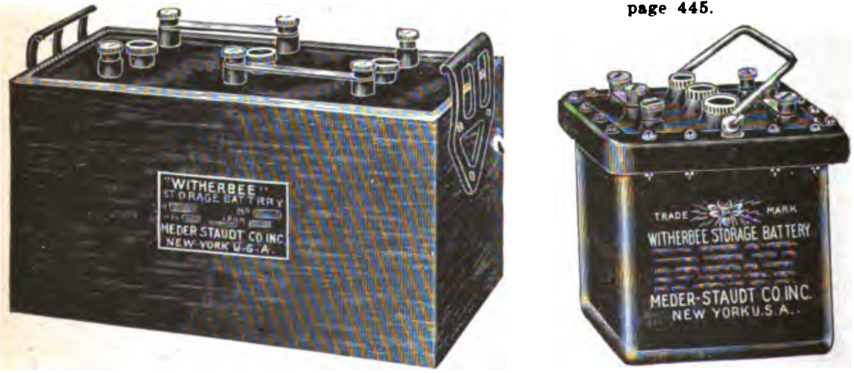


Fig. 5.—Showing the comparative size of an automobile ignition battery of 60 ampere-hour capacity (small one) and a lighting battery of 120 ampere hour capacity.

There are more plates and larger plates, however, to the 120 ampere size — hence, greater quantity or capacity.

Witherbee battery now manufactured by Witherbee Stg. Battery Co. 1904 Broadway, N. Y.

CHART 201—The Storage Battery. Plates; Faure and Plante types.

Charts 199 and 200 omitted by error.

See page 443 "Storage Battery Voltage."

INSTRUCTION No. 32.

THE STORAGE BATTERY: General Description. Size Battery to Use. Construction and Action. Electrolyte. Test Battery. Hydrometer and its Use. When a Battery Needs Charging. Testing with a Voltmeter. Care of a Battery. Specific Gravity. Freezing Temperatures. Baume Scale.

General Description.

Storage batteries are described as being devices for storing electrical energy, which may be used for various purposes. They do not store the current however, but generate electricity chemically as will be explained further on.

Storage batteries are also called "accumulators." They are also called "secondary" batteries.

The storage battery is used on automobiles for starting, ignition, lighting, operating the electric horn and various other purposes. The storage battery is used for starting the gasoline engine, by supplying current to an electric motor which revolves the crank shaft of engine. It is also used to operate an electric motor, which, in turn, propels an electric vehicle.

The storage battery used on electric vehicles consists of about 42 cells. The voltage of each cell is two volts, therefore 42 cells would give 84 volts pressure. The subject of electric vehicles is treated separately.

Ignition battery: The ignition storage battery is smaller than the lighting battery. The plates of the lighting battery are heavier and there are more of them. The average amperage of an ignition battery is 60 ampere hours and voltage is usually six.

Lighting battery: The amperage of a lighting battery is from 80 to 100 or more ampere-hour capacity, and voltage is usually six volts; sometimes 12, 16, 18 or 24.

There are usually three cells to the ignition and lighting battery, each cell giving two volts. These cells are placed in battery boxes, fig. 29, chart 203.

Starting batteries are similar in every respect to a lighting battery, except that the terminals are much larger in order to carry the extra heavy flow of current, as will be explained further on.

The starting batteries are furnished for 6, 12, 16, 18 and 24 volt systems, although the tendency at present favors the 6 and 12 volt size on the majority of cars.

Meaning of Amperes and Volts.

The meaning of amperes and volts is explained on page 207. The standard measure of the energy put into a battery is in terms of ampere-hours.

The capacity of a battery is measured in ampere hours. The volume of current flow is measured in amperes. A current of one ampere, flowing for one hour, is the unit by which capacity is measured, and is called ampere-hour.

Ampere is the unit of quantity, like a "gallon" of water. **Volt** is the unit of pressure, like "pounds." (See pages 207 and 208.

The ampere-hours obtainable from a battery depends upon the amount of current consumed by the ignition, starting or lighting system and the capacity or quantity of electricity the battery is made to deliver. Lowering the consumption and increasing the capacity of the battery, increases the ampere-hour capacity. The capacity of a battery is independent of its electrical pressure. Thus, a flow of 10 amperes, maintained for 8 hours, amounts to 80 ampere-hours.

***The ampere-hour capacity of a battery as stated, is dependent upon the rate of discharge.** The lower the rate, the greater will be the capacity. The same battery that has a capacity of 100 ampere-hours, at the 10 ampere discharge rate per hour, will have a capacity in excess of 100 ampere-hours if discharged at a lower rate, say of 5 amperes per hour.

An example: A certain battery will develop the following ampere-hour capacities at the indicated rates:

50.4 ampere hours at 3 ampere discharge rate for 16.8 hours.

42.5 ampere hours at 5 ampere discharge rate for 8.5 hours.

36. ampere hours at 7½ ampere discharge rate for 4.8 hours.

30. ampere hours at 10 ampere discharge rate for 3.0 hours.

Notice—See Instruction 29, page 428, for Removal of Battery when used with a generator on a car.

---

*See pages 327 and 427.

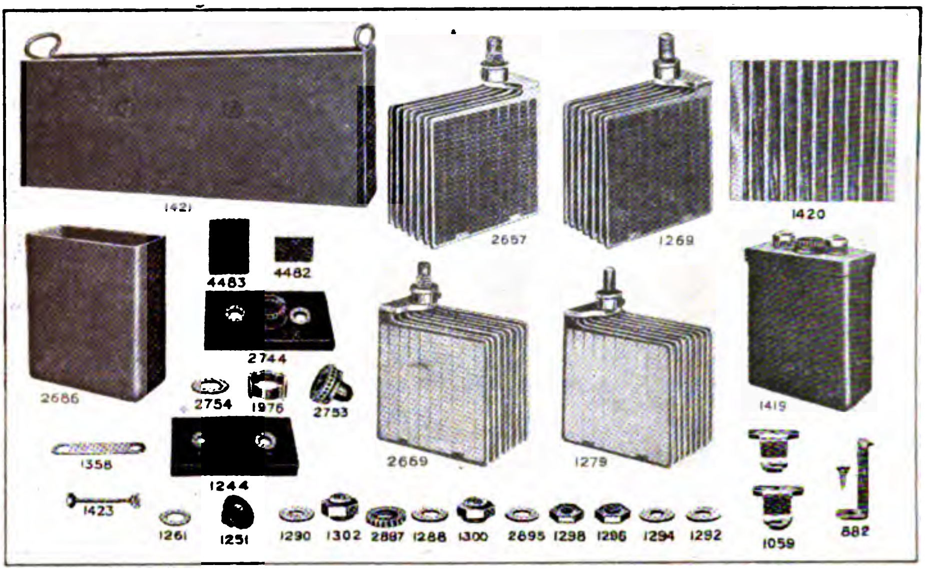


Fig. 1.—This illustration is used, to show the parts of a modern starting and lighting battery. It is the type 3-x-155-2 "Exide" make.

The Buick models: B-24, B-25, B-37, B-54 and B-55 cars use the above type and make.

Names of Parts.

1421—Wooden box in which cells are placed.
2657—Positive plate group (1 group per cell).
1269—Positive plate group (1 group per cell).
1420—Wood separator. Placed between + and — plates.
2686—Jar or cell casing. In which plates are placed.
4483—Large wood spacer. Placed between cells and case.
4482—Small wood spacer. Placed between cells.
2744—Jar cover. Same as 1244, only larger size.
2754—Filling plug gasket. Used to prevent leakage.
1976—Barrel for jar cover.
2753—Filling plug. Through which electrolyte is put in.
1358—Inter-cell connector. Joins + of one cell to — of another.
1244—Jar cover. Removed only to take out plates.
2669—Negative plate group (1 group per cell).
1279—Negative plate group (1 group per cell).
1419—Complete cell. Three used in 6 volt battery.
1423—Through bolt. Used to clamp cells in case.
1261—Filling plug gasket. Used to prevent leakage.
1251—Filling plug. Remove to put in electrolyte.
1290—Alloy washer. For negative terminals.
1302—Negative terminal nut. To fasten (—) lead wires.
2887—Alloy sealing nut. Put over terminals to prevent leakage.
1288—Alloy washer for positive terminals.
1300—Positive terminal nut. To fasten (+) lead wires.
2895—Gasket for terminals. One used under each sealing nut.
1298—Sealing nut for negative terminals.
1296—Sealing nut for positive terminals.
1294—Gasket for negative terminals.
1292—Gasket for positive terminals.
1059—Hold down clip. Used to hold case securely.
882—Hold down clip, same as above.

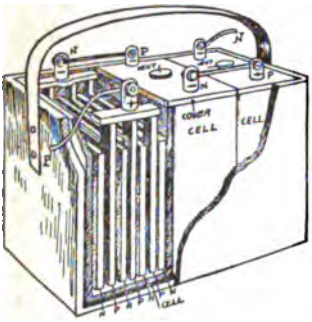


Fig. 20.

An element consists of a complete set of plates (2657 and 2669) burned together on strap, and wood and rubber separators; for a single cell. Positive plates (2657), are brown; negative plates (2669) are gray in color. There are 7 positive plates, which fit between the 8 negative plates, as shown in fig. 1 above.

Both the positive and negative plates are attached to what is termed the "positive or negative strap." In this particular battery; as an example; there are 7 positive and 8 negative plates. Notice how the plates are interposed, or alternately placed, in fig. 20.

If the battery is a large one and the discharge is heavy, such as for a starting motor, then these straps, connectors, lugs and terminals, must be very **large or heavy,** in order to carry the quantity of current necessary to do the work without heating.

There may be 13 or 15 plates to a lighting battery; 6 positive and 7 negative, or 7 positive and 8 negative—in fact this varies with different manufacturers.

Fig. 20.—An exaggerated drawing showing three hard rubber cells with three positive and four negative plates in each cell. The elements are placed in a hard rubber jar and are called "cells." The cells are then placed in a wooden box, the terminals properly connected, and it is then termed a "battery."

Note, all the positive plates are placed at one end and all of the negative plates are placed at the other end. The insulators, or separators, are placed between a negative plate and a positive plate.

The plates are immersed in a solution of sulphuric acid mixed with water, called **electrolyte.** Each cell delivers but two volts pressure, no matter how large or how small it may be. The quantity or amperage discharge, however, is governed by the size and number of plates.

When the lead lugs (N and P) are attached to the lead bar connecting the plate, they are burnt on; or melted together by an electric weld.

CHART NO. 202—Assembly of a Modern Storage Battery.

***Storage battery voltage:** A three-cell battery gives six volts, no matter what the size of the cell may be. The length of time it will maintain a certain current output, depends on the capacity, or electrical size of a battery; an ordinary jump spark coil requires about one ampere per hour, therefore a 60-ampere hour battery would operate for approximately 60 hours, as the discharge rate would be very low.

If we were to charge such a cell we would find that, regardless of the number of plates, the cell would exert on discharge an average pressure of 2 volts—that is; unless the imposed load in amperes was too heavy for the size of cell. At the beginning of discharge the pressure would be a little above 2 volts, and with the progress of discharge would gradually fall off to a little below 2 volts. So would the pressure of compressed air in a tank die down if you were to draw off some of the air.

Since the nominal voltage of a storage battery is 2 volts per cell, you can readily see that to make a 6 volt battery, we connect 3 cells "in series." And to make a 12 volt battery, we connect 6 cells "in series," which means that we join the positive post strap of one cell to the negative post strap of the next cell by means of a "link." This leaves one post in each of the two end cells. To these we fasten the terminal links of the battery, one positive, the other negative, for making bolted connections with the two cables or "leads" (pronounced "leeds") through which the battery receives and delivers energy.

How to Determine the Proper Size of Battery.

The first step in determining the proper size of battery for "lighting duty," is to decide upon the voltage of the lamps. Tungsten lamps, which consume about one third the current required by carbon lamps, should invariably be used. Table in chart 205-D shows the number of hours the various batteries will burn different lamp candle-powers, continuously on one charge. These values are calculated for tungsten filament lamps and are not applicable for carbon filament lamps.

The second step is to determine the amount of current that the battery will be required to deliver. Do this by ascertaining first, the number of lamps to be used, the voltage of each, and then determine the quantity of current each will take, then add the total, which will give the total amperage required.

In some cases not all the lamps will be operated at the same time and this should be taken into consideration. Allowance should also be made for any other current consuming devices that may be used.

Knowing the amount of current that the battery will be required to deliver, you can select a battery of the proper capacity by referring to chart 205D.

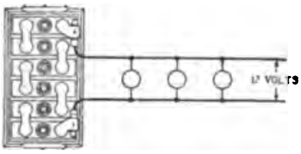
How to Determine the Number of Cells and Plates to a Cell, by the Number on Battery.

In the list of the U. S. L. battery for instance, the first letter stands for a certain general type or construction. For example in type C-607, the letter "C" indicates the use of "C" plates, "C" jars, "C" covers, etc. The last two figures, signify the number of plates per cell, and the first figure, signifies the number of cells in the battery. Thus, battery type C-607 has 6 cells of 7 plates each; type A-317 has 3 cells of 17 plates each. The suffix; or right hand letter; indicates a particular assembly or arangement of the jars in the battery box. For example, the letter "B" in type C-607-B indicates that the 6 jars are assembled side by side in the battery box.

Exide: starting, lighting and ignition batteries: Take, for instance, the 3-XC-13-1 battery. The first number "3" signifies the battery is made up of three cells; the letters "XC" signify that the plates, separators, jars, covers, etc., which go to make up the battery, are of the type known as "XC;" the number "13" signifies that there are thirteen plates in each cell; the figure "1" signifies that the cells are assembled in the wood case side to side, this being known as No. 1 assembly. When the cells are assembled end to end the assembly is known as No. 2. The same method of designation is followed out in the LX and SX batteries, also listed in the table of "Exide" batteries.

Construction.

Cell assembly: The cells can be assembled sidewise, or endwise; as shown in chart 203.



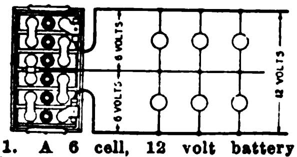


Fig. 1. A 6 cell, 12 volt battery using 12 volt lights.

Fig. 2. A 6 cell, 12 volt battery using 6 volt lights. Note the "neutral" link in the center.

Cells in case: The cells are placed in a sturdy wood case fitted with lead coated, acid-resisting handles and the whole outfit covered with acid proof paint. On all sides of each cell is a packing of sealing compound—a pitch-like substance to support the jars evenly and to exclude acid or water, which may carelessly be slopped over the battery and which would eventually ruin it.

Cell connections: All cells are connected in series, as shown in figs. 1 and 2. It is possible however, to connect the cells so that lower voltage lamps can be used on a higher voltage battery. This is explained above and in chart 205-C. It is important to note that in using a battery with a "neutral" connection the load ought to be divided equally, see chart 205-C.

---

*See page 440.

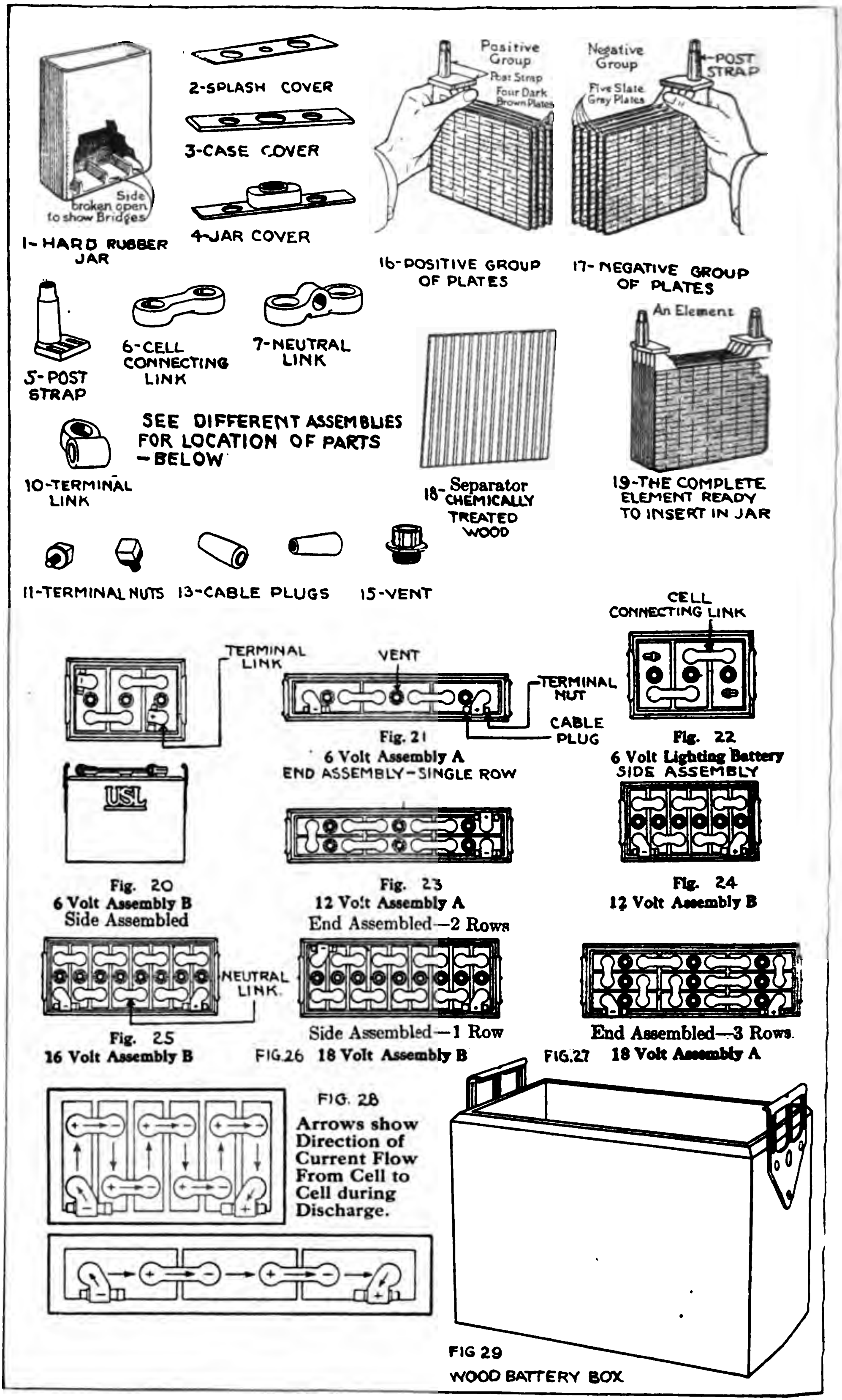


CHART NO. 208—Parts of a Storage Battery Cell. How the Cells are Assembled "Side by Side" also Endwise; in Single, Double and Three Rows. The U. S. L. as an example.

and burned joints. The way lead parts fastened together, for example; where es and links are jointed to post straps fig. 17 and 6, chart 203) is by "lead ning." A hydrogen gas flame is played n each junction and fuses the parts into solidly united piece (see also chart -F).

Cells.

jar with parts installed, is called a cell. 7 plate cell includes 4 negative and 3 itive plates; a 9 plate cell has 5 negaes and 4 positive and so on.

Parts of a cell: Jar itself, see fig. 1, rt 203, is made of hard rubber with dges at the bottom. The element or tes rest on these bridges. If some of paste falls from the plates, which is med sediment, it will not short circuit plates, that is, connect from one to the her, unless the sediment is allowed to acmulate to such an extent that it touches e plates.

The other parts of a cell are the plates, ith wood separators, connection links, rminal link, nuts, vent caps, cover, etc.—e charts 203 and 202.

There is one group of positive plates and ne group of negative plates, to each cell. he positive group is shown in fig. 16, hart 203 and the negative group, fig. 17. he two groups are interleaved with separators.

Cell Assembly.

†Plates: There are two kinds of plates; he Faure-type and the Plante-type. The aure-type is the pasted type and is the late in general use. The Plante-type, fig. , chart 201 is obsolete. Therefore we shall eal with the modern type only.

The plates are different in color, the positive (lead oxide) being a deep chocolate color and the negative a gray (pure lead).

The plates are pasted and formed in groups as will be explained. See figs. 5 and 6, chart 203A for a positive and a negative plate of the Exide make.

Grid: A grid made of a stiff lead alloy supports the active material pasted in between the slots in the form of a series of vertical strips, held between the grid bars and locked in place by horizontal surface ribs, staggered on the opposite sides. Fig. 8, chart 203A, shows a section through the horizontal ribs and makes clear their staggered relation.

Material: After the grids are cast they are "pasted" with oxides of lead, made into a †paste of special composition which sets in drying like cement. The plates then go through an electro-chemical process called "forming the plates," which converts the material of the positives into brown *peroxide of lead, and that of the negatives into gray, spongy lead. Fig. 5 (chart 203-A) shows the finished positive plate and fig. 6 the negative.

Lugs: Both the positive and negative plates are provided with an extension or "lug," and they are so assembled that all the positive lugs come at one side of the jar and all the negative lugs at the other, thus enabling each set to be burned together with a connecting strap giving one positive and one negative pole. The burning is done by a hydrogen flame, which melts the metal of both lugs and strap into an integral union.

Group: A set of plates burned to a strap is known as a "group" (fig. 7, chart 203A), either positive or negative. Figs. 16 and 17 chart 203, also shows a positive and a negative group. The two groups are interleaved with separators between them and the assembled group, fig. 19, is called **the complete element.**

Straps: The straps (fig. 7) are made of a hard lead alloy and are provided with posts to which the cell connections are made.

Separators: When the positive and negative groups are assembled together, the adjoining plates are insulated, or kept out of contact by means of wood separators ribbed side against the positive. The separators (fig. 8) are made of tough wood particularly adapted for the purpose and given a special treatment to remove harmful substances.

Element: A positive and a negative group together with the separators constitute an "element" as explained above. See fig. 19, chart 203 and fig. 9, chart 203A.

Electrolyte: The fluid, known as "electrolyte" is dilute sulphuric acid. The element is placed in the jar with the electrolyte.

Jar: The cell container is a rubber jar of special composition which will withstand the vibration of the car and any ordinary handling without breakage. The plates rest on stiff ribs or bridges in the bottom of the jar (fig. 1) allowing space for the gradual accumulation of "sediment."

Cover: The jar cover and method of sealing and venting is very important. The cover on the "Exide" battery is flanged in such a way as to give a more perfect seal to the jar than the old flat type of cover, and each cell is a separate sealed unit.

Vent: From the illustration (fig. 10, chart 203A) of the vent and filling plug, it will be seen that they provide both a vented stopper (vents F, G, H) and an automatic device for the prevention of overfilling and flooding.

Case: The case in which the cells are assembled into a battery is built of hard wood, thoroughly coated with acid proof paint, see fig. 2.

Hold-down clips: It is **absolutely essential** that the battery be securely held in position on the car, and for this purpose brackets which fit on the case are used. The battery is made fast to the car by means of bolts engaging the hold-down clips. (see 1059, chart 202).

Terminals: The **positive terminal** is marked (+) and can always be determined by the dark color. The **negative terminal** is a light gray color and is marked thus (—).

---

*Oxide of lead is 1 part oxygen and 1 part lead. Peroxide of lead is 2 parts oxygen and 1 part lead.

†See foot note pages 446, 447.

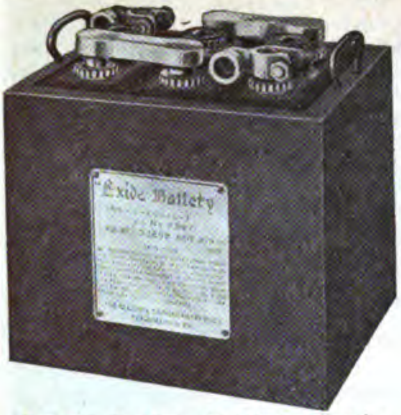


Fig. 2.—Starting and lighting battery. Note the heavy connections. (Exide type 3-XC-13).

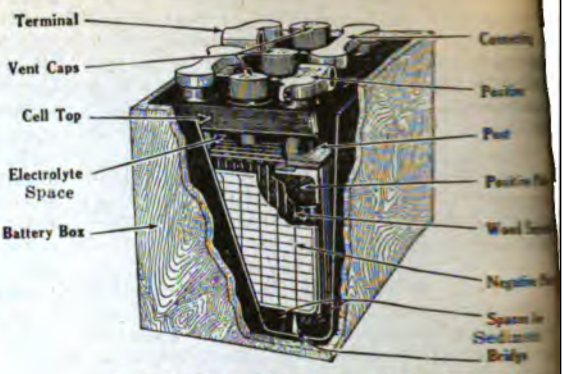


Fig. 1.—A 3-cell battery; shown in sectio

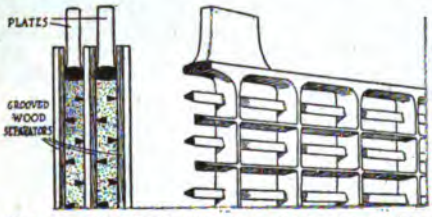


Fig. 3.—The lead grid, on which the active material is pasted. Illustration shows only the upper part.

Fig. 5. Positive plate, brown or dark.

Fig. 6. Negative pl grey or light colo

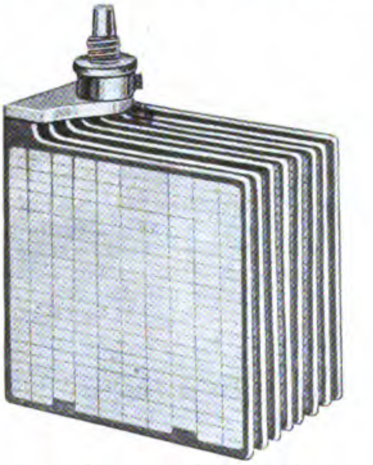


Fig. 7.—Group of Plates with strap burned to plates and to connecting lug.

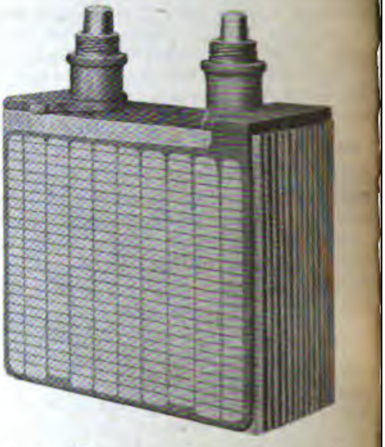


Fig. 9.—Two groups, or the negativ and positive plates, are called element The separators are placed between.

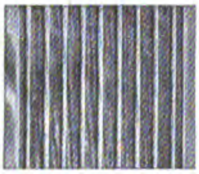


Fig. 8.—Separators, which are placed between the plates.

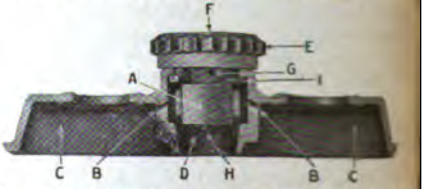


Fig. 10.—Sectional view of cover, plug in pla Air lock (A) in position to allow free escap gas through passages (BB).

CHART NO. 203-A—Parts of a Modern Lighting and Starting Battery. (Exide as an exam (The Electric Storage Battery Co., Philadelphia, Pa.)

The reason there is an odd number of plates in a cell, is due to the fact that there is one more negative pla positive. A negative plate is placed at each end so that there will be action on both sides of all positive pl The positive plates are thicker and have more active material. The positive plates also have a tendency to from the negative and if were placed at the end, it would buckle and bend away from the negative plate—s 16, 17, page 444 for arrangement of plates.

Forming the Plates.

is is a subject which concerns the ufacturer, but we will give a brief ne of how the plates are formed after nbling. Different manufacturers use rent processes.

Vhen the elements are placed in the jar, immersed in 1300 sp. gr. electrolyte, are "formed"* by passing an electric ent (direct only) at a very low rate a long period of time.

Another method of forming is to leave battery stand for 24 hours, then start charging at 1/18 of the capacity and charge continuously for 150 hours.

The plates go through what is called an electro chemical process that converts the paste on the positive plate into ****brown peroxide of lead**, and the paste on the negative plate into **gray spongy lead**.

Action of a Storage Battery when Charging and Discharging.

Then charging a battery the electricity ot being stored, as thought by some, or the name would imply. The action is ely chemical, and the current given off generated by chemical action.

eneral: A storage **battery** consists of or more cells. A cell consists essenlly of positive and negative plates imsed in an electrolyte.

mplified meaning of specific gravity: e electrolyte of the cell consists of a xture of sulphuric acid and water. **ter is lighter than acid, therefore a hymeter would sink deeper in water, than acid.**

The more acid in the water, the less depth e hydrometer would sink. This depth at the hydrometer sinks, is shown on a aduated scale, and is designated "sp. gr." simply "SG." (specific gravity).

The **voltage** of one **cell** is about two volts. he **voltage** of a **battery** (with cells in "sers") is the number of cells multiplied by wo. (see page 440).

When a cell is being used, the current is roduced by the acid in the electrolyte, oing **into** and combining with **the lead** f the porous part of the plates, called the 'active material.'' †In the positive plate, he active material is lead peroxide, and in he negative it is metallic lead in a spongy orm.

Formation of lead sulphate: When the sulphuric acid in the electrolyte combines with the lead in the active material, a compound "lead sulphate," is formed.

As the discharge progresses, the electrolyte becomes weaker, due to the fact that the **acid goes into the plates,** producing the electric current and incidentally producing the compound of acid and lead, called "lead sulphate." This sulphate continues to increase in quantity and bulk, thereby filling the pores of the plates.

Drop in voltage: As the pores of the plates become thus filled with the sulphate, the **free circulation of acid into the plates is retarded**; and since the acid cannot then get into the plates fast enough to maintain the normal action, the battery becomes less active, as is indicated by the **drop in voltage** or a discharged condition.

Why a hydrometer is used to test the electrolyte or solution:—The specific gravity of water is 1000. If acid is mixed with water it will become heavier. A hydrometer would not sink as deep into the heavier solution as it would in a thinner or lighter solution.

When battery is fully charged the specific gravity would be 1285 to 1300 as the acid is out of the plates in the solution. When a battery becomes discharged the plates absorb the acid and the solution becomes thinner, therefore the hydrometer would sink as low as 1150 sp. gr., or a drop of nearly 150 points, if fully discharged.

In other words, the acid will be in the plates and the electrolyte will be reduced to almost mere water. Hence the necessity of occasionally testing with a hydrometer.

Charging Action.

To charge, direct current is passed hrough the cells in a direction opposite o that of discharge. This current, passing through the cells in the reverse direcion, will reverse the action which took lace in the cells during discharge. It will e remembered that during discharge, the **cid of the electrolyte went into and comined with the active material,** filling its pores with sulphate. and causing the electrolyte to become weaker (merely water).

Action of current: Reversing the current through this sulphate in the plates restores the active material to its original condition and **returns the acid to the electrolyte.**

Thus, during charge the electrolyte gradually becomes stronger, as the sulphate in the plates decreases, until no more sulphate remains and all the acid has been returned to the electrolyte. It will then be of the same strength as before the discharge and the same acid will be ready to be used over again during the next discharge. **Since there is no loss of acid, none should ever be added to the electrolyte.** There is, however, a loss of water from evaporation.

Object of charging: The acid absorbed by the plates during discharge is, during charge, driven from the plates by the charging current and restored to the electrolyte. This is the whole object of charging.

Gassing: When a battery is fully discharged, it can absorb current at the highest rate. As the charge progresses, the plates can no longer absorb current at the same rate and the excess current goes to form gas. In a battery which is charged or nearly charged, the plates can absorb current without excessive gassing only at a low rate and **a high charging rate will be almost entirely used in forming gas, resulting in high temperature and wear on the plates.**

---

*If plate is very hard it would be necessary to charge and discharge many times.

**See foot note bottom of page 445. †See foot note page 446.

†The paste on the grids is made of red lead and weakened solution of sulphuric acid for the positive plate and litharge and weakened solution of sulphuric acid for the negative plate.

In starting and lighting systems, the aim is to provide sufficient current under average running conditions so that the battery will not be "starved," and yet the charge will be at a rate which will not cause injurious gassing.

Normal and abnormal sulphate: The sulphating which takes place during an ordinary discharge, is entirely normal. If, however, charging is insufficient, the sulphate increases and becomes hard and the plates become lighter in color, lose their porosity and are not easily charged; this is the abnormal condition usually referred to as "sulphated." This condition is usually the result of "starvation" of the battery.

High rates of discharge: A very general misapprehension has existed in the past as to the effect on a lead storage battery of discharging at very high rates. The fact that a starting battery will spin one of the big modern engines which a strong man can scarcely turn over shows what its capabilities are; and the length of time it will with proper charging and care continue to do this heavy work without giving out shows that it is not injured thereby.

Overdischarge: It is not discharge at any rate which injures a battery, but **overdischarge**, or, what in time amounts to the same thing, undercharge or "starvation."

"Starvation:" If a car is so run that the battery gets insufficient charge and is "starved," it cannot be expected to do its work properly.

Overcharge: Persistent overcharging not only tends to wash out the positive active material, but also acts on the p grids, giving them a scaly appearance

Low temperature: Temperature has a marked effect on a battery. Low perature (temporarily) both lessens ampere hour capacity which can be out of the battery and lowers the disc voltage. It is as if the battery were by the cold and unable to make the effort as at normal temperature. Th fect of cold is only temporary, the b returning to its normal state upon it turn to normal temperature even wi charge. Starting batteries are usually signed with sufficient margin over the ary requirements so that they will still form their functions under reasonably temperature conditions. It is just as however, to bear in mind the effect of weather and to aim to keep the ba unusually well charged in winter and expose it unnecessarily to low tempera

There is no danger of the electrolyte f ing in a fully charged cell; but in which is over discharged or has had added without subsequent charging th liable to occur.

High temperature: High temperatur to be avoided from the standpoint of 110 degrees Fahrenheit is usually give the limiting temperature, and even would be harmful if maintained stead

Heating is ordinarily the result of cha ing at too high a current rate. If the te perature of the electrolyte in a battery found to run excessively high, the syste should be inspected; it may be out of a justment and be charging the battery too high a rate.

The effects of continued high temperat are to distort and buckle the plates, to ch and weaken the wood separators, to soft and sometimes injuriously distort the ja and covers.

Electrolyte.

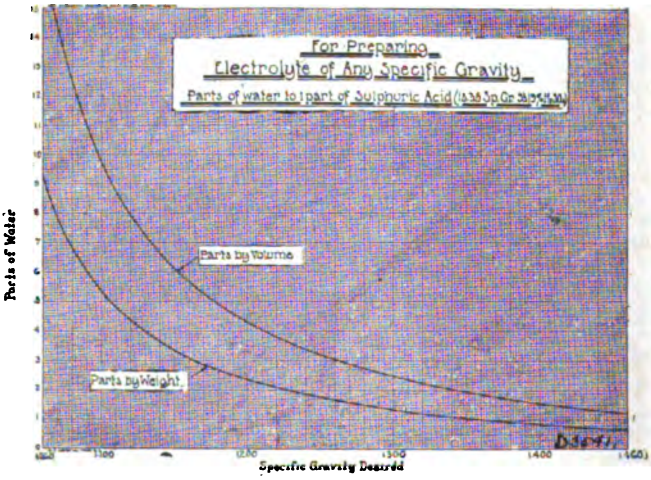


Fig. 11—How to read: If a solution of electrolyte of 1.250 sp. gr. is desired—see 1.250 at bottom—then go straight up to upper curved line (parts by volume)—then straight to the left following horizontal line—and you have 3¼ parts water to 1 part sulphuric acid.

Composition: Electrolyte as used in all types of batteries consists of a mixture of pure sulphuric acid and distilled or other pure water and is the liquid solution used in storage batteries.

Concentrated sulphuric acid is a heavy, oily liquid having a specific gravity of about 1.835. A battery will not operate if the acid is too strong and it is therefore diluted with sufficient pure water to bring it to a gravity of 1.270 to 1.300 for a fully charged battery. Stronger electrolyte than this is injurious.

To prepare electrolyte from sulphuric acid of 1.835 specific gravity, mix with water in the proportions in-

When adding new electrolyte to a repaired or cleaned battery, see page 470.

ated in fig. 11 for the desired specific **vity**, taking the following precautions:

(1) A glazed stone vessel or a lead lined tank uld be used.

(2) Put the water in the vessel first.

(3) Fill the hydrometer syringe with chemily pure sulphuric acid and add it to the water holding the nozzle under the surface. Stir the ution with a glass rod or clean piece of wood.

(4) Rinse the syringe and test the strength of solution. If it is about 20° Baume allow it cool, when it will be stronger.

(5) If not strong enough, add more acid.

(6) If too strong, add water.

(7) The pure acid should not be allowed to main in the syringe.

Chemically pure electrolyte: Both the water and the sulphuric acid used in making electrolyte should be **chemically pure** o a certain standard. This is the same standard of purity as is usually sold in drug stores as "CP" (chemically pure) or by the chemical manufacturers, as "battery acid."

In this connection, the expression "chemically pure" acid is often confused with acid of "full strength." Acid may be of full strength (approximately 1.835 sp. gr.) and at the same time chemically pure. If this chemically pure acid of full strength be mixed with chemically pure water the mixture would still be chemically pure, but not of full strength. On the other hand, if a small quantity of some impurity be introduced into chemically pure acid, it would not materially reduce the strength, but would make it impure.

The usual method of determining the strength of electrolyte is by taking its specific gravity. The method is possible on account of the fact that sulphuric acid is heavier than water. Therefore the greater the proportion of acid contained in the electrolyte, the heavier the solution, or the higher its specific gravity.

Specific Gravity.

By specific gravity is meant the relative weight of any substance compared with water as a basis. Pure water, therefore, is considered to have a specific gravity of 1, usually written 1.000 and spoken of as "ten hundred." One pound of water is approximately one pint. An equal volume of concentrated sulphuric acid (oil of vitriol) weighs 1.835 pounds. It therefore has a specific gravity of 1.835 and is spoken of as "eighteen thirty-five."

Temperature Correction.

Since electrolyte, like most substances, expands when heated, its specific gravity is affected by a change in temperature.

If electrolyte has a certain gravity at a temperature of 70 degrees Fahrenheit and it be heated, the heat will cause the electrolyte to expand, and, although the actual strength of the solution will remain the same as before heating, yet the expansion will cause it to have a lower gravity, of approximately one point (.001) for each three degrees rise in temperature.

For instance, if electrolyte has a gravity of 1.275 at 70 degrees Fahrenheit and the temperature be raised to 73 degrees Fahrenheit, this increase in temperature will cause the electrolyte to expand and the gravity to drop from 1.275 to 1.274.

On the other hand, if the temperature has been lowered from 70 degrees to 67 degrees, this would cause the gravity to rise from 1.275 to 1.276.

Since the change of temperature does not alter the actual strength of the electrolyte, changing its gravity only, the gravity reading should be corrected one point for each three degrees change in temperature.

Electrolyte becomes lighter, or of lower "gravity" as it gets warmer and vice versa, and this rise or fall of "gravity" effected by temperature change is independent of the state of charge. "Temperature corrections" are unnecessary when you compare the "gravities" of the different cells of battery at any one time, since all have about the same temperature when in health and so are affected alike. Temperature corrections are also unnecessary, when you use the hydrometer, say testing the middle cell, which we will call the "pilot cell," to secure an approximate index of the battery's condition. That is, corrections are in general unnecessary, except when there is reason for a really critical study of the battery's condition, as when you suspect things are not going well with the battery.

Note too that the actual proportion of water in the electrolyte slightly affects the "gravity" independently of the state of charge. That is, the more water there is the lower the gravity. Therefore to derive the greatest benefit from your hydrometer readings try to keep the electrolyte surface between a point ¼ inch above the plates and the electrolyte level designated for your battery, either on the name plate or in the instruction pamphlet you receive with the battery. Use the glass tube level-tester (page 455), consistently in conjunction with your hydrometer and add water promptly when it is needed.

Standard temperature: The temperature adopted as the standard for a basis of comparison of specific gravities of electrolyte is 70° F. Thus, when we say that a specific gravity of 1.280 indicates full charge and 1.225 indicates practical discharge for **starter** purposes or 1.150 total discharge, we mean that these are the "gravities" when the electrolyte has a temperature of 70° F.

Thermometer its purpose—Suppose you test the specific gravity at a time when a thermometer inserted in the electrolyte shows the latter to be warmer than 70° F. Note the hydrometer reading and add one point to the fourth figure for every three degrees that the thermometer shows the electrolyte to be warmer than 70° F. This corrects your reading to what it would be if the electrolyte temperature were 70° F. at that time. If the electrolyte is colder than 70° F., one point should be subtracted from the fourth figure for every three degrees that the temperature of the electrolyte is below 70° F.

Example A. Temperature of electrolyte is 100° F. Hydrometer reading is 1.275. Then 100°—70°=30° and 30÷3=10 and corrected reading is 1.275 plus .010=1.285.

Example B.. Temperature of electrolyte is 40° Hydrometer reading is 1.235. Then 70°—40°=30° and 30÷3=10 and corrected reading is 1.235 minus .010=1.225.

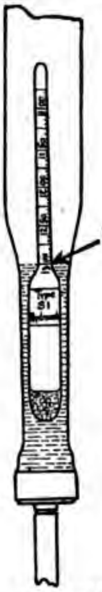


Fig. 17
Hydrometer
Reading 1.300

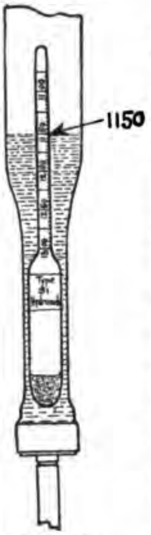


Fig. 18
Hydrometer
Reading 1.150

**Testing Condition of a Storage Battery with a Hydrometer Syringe.

The hydrometer syringe is the best method for testing the condition of the electrolyte. The specific gravity (abbreviated as sp. gr. meaning the density) of the solution, should be tested in **each** cell. This should be done regularly, and the best time is when adding water, but the reading should be taken **before**, rather than after **adding the water.**

If the electrolyte is below the top of the plates, or so low that enough cannot be drawn into the barrel to allow of a proper reading of the hydrometer, fill the cell to the proper level by adding pure water; then do not take a proper reading until the water has been thoroughly mixed with the electrolyte by the **gassing** at the end of **a recharge.**

Manipulation. The hydrometer is the glass tube with a graduated scale reading, as shown in fig. 1, (also see fig. 3, chart 204-A). The syringe is a glass tube with a rubber bulb at the top and a rubber tube for injecting into the vent opening of cell. Enough electrolyte is drawn into the glass tube to float the hydrometer. Fig. 15 illustrates three positions the hydrometer will assume when floating in the electrolyte.

In using the hydrometer, certain points should be kept in mind. In the first place, the liquid taken up by the hydrometer from one cell, should never be put into another cell, as this will be likely to cause some trouble, due to "high acid" in one cell, or due to weakened electrolyte in another. Also care should be taken when using the hydrometer, not to have any air bubbles form in the cell, as it is very difficult to get these out, and as a result, the extra electrolyte is spilled. When heated up, the bubbles disappear and the level of the electrolyte sometimes falls below the tops of the plates.

When all cells are in good order, the gravity will test about the same (within 25 points) in each cell. (Note; gravity readings are sometimes expressed in "points," thus the difference between 1.275 and 1.300 is 25 points).

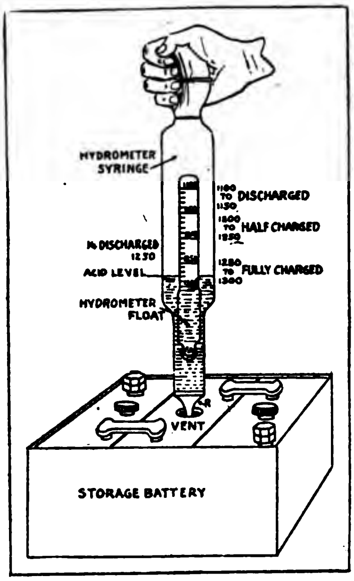


Fig. 15.—An exaggerated illustration showing how the pressing of the rubber bulb draws electrolyte from the cell, and how the hydrometer floats in the glass barrel. The level of the electrolyte when registering even with the figures indicates the specific gravity. If the electrolyte is heavy with acid the hydrometer will not sink as deep as when the acid is in the plates. See pages 447, 449 and 451 for use of the hydrometer.

*Hydrometer Readings.

A fully charged battery will be indicated by the hydrometer reading sinking to a level in the electrolyte anywhere between 1.280 and 1.800.

A half charged battery, the gravity will be 1.225.

A discharged battery, the gravity will be 1.150.

The storage battery will rarely crank an engine if its specific gravity falls below 1.200, although the lights will be nearly as bright as with a fully charged battery. When fully charged, its specific gravity should be between 1.280 and 1.300. **As a rule, when fully charged,** the specific gravity will be nearer 1.280 than 1.300, especially when the battery has been in use for some time.

One manufacturer states that when the battery is used for **starting service** the battery is practically **exhausted** or incapable of starting with as low as 1.225 gravity test. But for lighting and ignition where the amperage rate of discharge is very low, the reading could be 1.150 when exhausted. See foot note page 451.

A run down battery should be given a full charge at once.

A voltmeter can also be used to test the cells while on a charge per page 453, or on discharge as explained on pages 416 and 410

The "Cadmium Test" is used to test which set of plates are defective, when the battery will not hold its charge—see index.

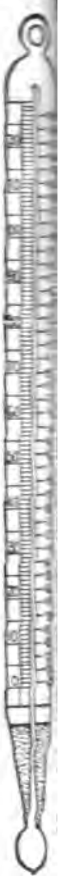


Fig. 12
[illegible]

Thermometer.

Fig. 12—A special thermometer for readings, as per text, pages 449-458.

On opposite side of the mercury column and parallel to the temperature scale; that is, opposite to the temperature 70 degrees is figure 0, showing that nuo correction of gravity readings is made at that temperature.

Three degrees below 70 degrees is shown minus 1, indicating that the gravity should be corrected at that temperature by deducting one point.

Three degrees above 70 degrees is shown plus 1, which indicates that the gravity at that temperature should be corrected by adding one point to the reading, as shown by the hydrometer.

The temperature of electrolyte is a very important consideration when using a hydrometer for testing the gravity—hence the use of the above thermometer and explaination on pages 449-458.

---

*For a comparison of the Baume and specific gravity scale, see fig. 4, chart 204-A.

**See page 447; "Why a Hydrometer is Used For Testing" and 449; "Thermometer, Its Purpose."

CHART NO. 204—The Hydrometer for Testing the (sp. gr.) Specific Gravity of Electrolyte. How to Test. The Hydrometer Syringe. The Thermometer.

**For cadmium tests, see index, also pages 416 and 410.

A Special Thermometer.

With a special scale on which the amount **correction** is figured out is shown in fig. **2, chart** 204. (Manufactured by the Elec-ric Storage Battery Co., Philadelphia.)

†Freezing of Electrolyte.

The freezing point of electrolyte depends pon its specific gravity. There is little **anger** of freezing except with a discharged **attery.**

Water will freeze at 32° Fahrenheit. Hence, **the** battery were to be discharged by some **neans** to the point of where the electrolyte is **ear** the gravity of water, the electrolyte would **of** course freeze near this point.

In order to avoid freezing of the electrolyte, it **hould** always be kept in a fully charged condition.

A fully charged battery will not freeze in temperatures ordinarily met. **Electrolyte will freeze as follows:**

Sp. gr. 1.150, battery discharged, 18 degrees above zero.

Sp. gr. 1.160, battery ¾ discharged; zero.

Sp. gr. 1,225, battery ½ discharged; 38 degrees below zero.

Sp. gr. 1.260, battery ¼ discharged; 60 degrees below zero.

Sp. gr. 1,280 to 1.300, battery fully charged; 100 degrees below zero.

When a battery is stored away for the winter, care should, therefore, be taken that the battery is kept in a fullly charged condition.

If the electrolyte becomes frozen, the expansion will sometimes break the jar, if not, simply place it in a warm place and it will come back to its normal charge. It is best, however, to recharge it first and then pour out the old electrolyte and put in new electrolyte of specific gravity of 1.300.

The Hydrometer.

The specific gravity or density of the electrolyte is measured by an instrument called the "hydrometer"—see pages 447, 449.

This consists of a closed glass tube in the form of a short barrel with a longer stem of small diameter. Inside of the stem is a graduated scale and at the lower end a few small shot are placed—see page 450.

The hydrometer floats upright in the liquid and the point on the scale at the surface of the liquid shows the specific gravity, usually called "gravity."

Method of use: For greater convenience, the hydrometer is usually placed inside of a larger glass barrel provided with a rubber bulb on top and a suitable nozzle on the lower end. This combination is known as the "hydrometer syringe" (fig. 15, chart 204).

By squeezing the bulb, inserting the nozzle into the electrolyte and releasing the bulb, electrolyte is drawn up into the glass barrel. Sufficient should be drawn up to float the hydrometer clear of the rubber plug in the bottom.

To prevent the hydrometer from sticking to the side of the barrel, it is necessary that the syringe be held in a vertical position. The reading is taken at the surface of the electrolyte and when there is no compression on the bulb.

In recording the gravity of the different cells, it is customary to begin with the cell at the positive end.

When the readings have been taken, be careful to put the electrolyte back into the same cell from which it was taken. Failure to do this often leads to trouble; that is, electrolyte is often taken out of one cell, the gravity noted and the electrolyte put back into another cell. The result is that the amount of electrolyte taken out of the first cell is eventually replaced with water, leaving the electrolyte weaker; whereas the electrolyte which was taken out and put into another cell would make the electrolyte of that cell stronger, resulting in irregularity in the different cells.

When to take a hydrometer reading: Take a hydrometer reading of each cell with the hydrometer syringe at least once a week and **just before adding water.**

If hydrometer readings are taken after adding water and before the car is run, they are of no value, as only water or very weak electrolyte will be drawn into the syringe. This is due to the water being lighter than the electrolyte, and therefore remaining on the surface until thoroughly mixed by running the car.

Take hydrometer readings at any time that any part of the **electric system does not work properly,** as they may indicate the trouble.

*Hydrometer Readings.

This information is given in chart 204 and as follows:

Specific gravity—1.280...... fully charged
Specific gravity—1.260...... three-quarters
Specific gravity—1.225........... one-half
Specific gravity—1.160......... one-quarter
Specific gravity—1.150......... discharged

An exhausted battery should be removed from the car and given a full charge.

When the gravity will not rise above 1.225 or 1.250 from generator charge on car—this may be due to excessive use of lights, together with slow running of the car, which cuts down the charging current from the generator, or it may be due to trouble in the system—see pages 422, 457.

The remedy is to use lights sparingly, until the gravity rises above 1.250. If gravity will not rise above 1.250 within a reasonable time, look for trouble in the system.

---

*Where battery is used for starting motors 1.275 to 1.300 sp. gr. at 70° F.—is the "full charge," or top mark for battery specific gravity. A battery with gravity below 1.225 can hardly inject the requisite energy into the starter to spin the engine, so that 1.225 is the practical low mark.

Then 1.280 minus 1.225=.055, termed 55 points, covering the range between full charge and complete discharge.

Of course, a battery with gravity below 1.225 can operate the lights at a lower gravity. Suppose you try a hydrometer diagnosis and find the reading to be 1.255. Then 1.280 minus 1.255 equals 22½ out of the 55 points of full range, from which you know that your battery is half charged or half discharged. 1.260 indicates three quarters charged or one quarter discharged.

†A battery's capacity is considerably less during zero weather than summer heat—see page 422.

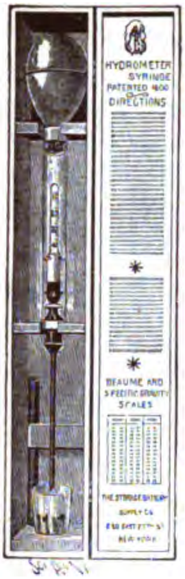


*Fig. 1—Hydrometer syringe outfit for shop use.

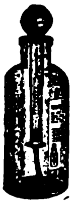


Fig. 9. The "Workrite" hydrometer outfit sells for $1.50 including hydrometer. Hydrometer is placed in bottle with distilled water.

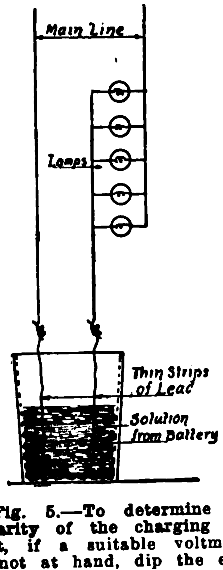
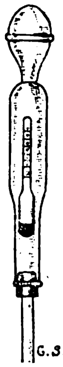


Fig. 5.—To determine the polarity of the charging circuit, if a suitable voltmeter is not at hand, dip the ends of the two wires into a glass of water in which a teaspoonful of salt has been dissolved, care being taken to keep the wires at least an inch apart. When current is on, fine gas bubbles will be given off from the negative wire.



Types of Hydrometers.

Two types of hydrometers are shown in fig. 1 and fig. 2. Fig. 1 is a large size garage outfit, whereas No. 2 is a smaller outfit.

Fig. 3, shows a Baume scale on the left and a specific gravity scale on the right. The comparison is shown in fig. 4.

"The "electrolyte" tester. Fig. 3 gives an arbitrary reading without showing the exact scale of the liquid in degrees, thus likened to the floating or sinking of an egg in brine to determine its strength, and is recommended for small batteries where it is not essential to get the exact specific gravity.

The glass balls in the instrument are hollow, and are accurately calibrated to float or sink in a certain strength of acid, and as mentioned in the description, they show by floating or sinking the condition of the acid near enough for all practical purposes and have the further advantage of requiring the least amount of acid to make the test.

It requires only a tablespoonful of acid, and the acid is returned to the cell without removing the instrument from it.

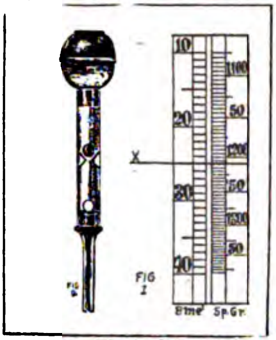


Fig. 3.—Electrolyte tester. Fig. 1 shows a Baume scale on the left and a sp. gr. on the right—see table below.

Directions for testing battery with an "electrolyte tester." Compress the bulb and insert the nozzle through the cover of the battery and allow the acid to fill the tube.

If the acid is at its proper strength 30 to 32 degrees Baume or 1.260 to 1.280 specific gravity both balls will remain in the center of the tube when the battery is fully charged.

If both balls float, the acid is too strong and it should be reduced by adding water.

If both balls sink when the battery is discharged, the battery should be fully charged, and then if the white ball does not float, stronger acid should be added.

Finding Polarity.

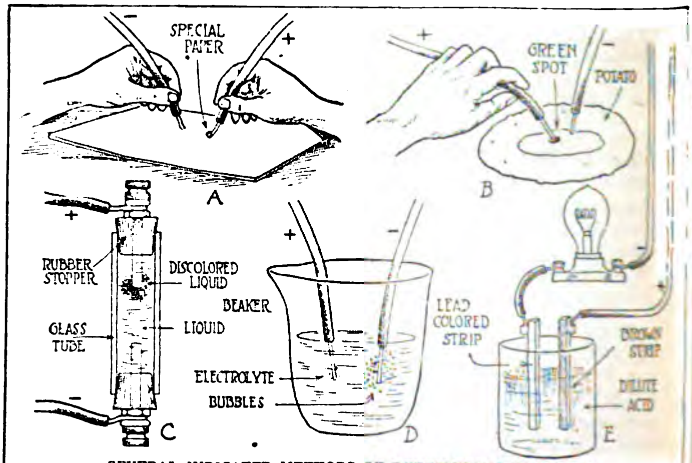
It is necessary to know the positive (+) and the negative (—) pole of a battery when charging.

To find polarity, or which is negative (—) and positive pole (+) of electric wires or battery terminals several methods can be used. Best plan is fig. 5. Others are shown in **A**, which is a special paper which shows a color for negative and different color for positive; **B**, the potato if skin is off will show green for positive; **C** D and E show other methods.

The storage battery polarity can be told by color of terminals. Positive (+) is a dark color and negative (—) light color.

FIG. 4 COMPARISON OF THE BAUME AND SPECIFIC GRAVITY SCALES AT 60° FAHRENHEIT.

Degrees Baume	Specific Gravity	Degrees Baume	Specific Gravity	Degrees Baume	Specific Gravity	Degrees Baume	Specific Gravity
0	1.000	17	1.133	34	1.306	51	1.542
1	1.007	18	1.142	35	1.318	52	1.559
2	1.014	19	1.151	36	1.330	53	1.576
3	1.021	20	1.160	37	1.343	54	1.593
4	1.028	21	1.169	38	1.355	55	1.611
5	1.036	22	1.179	39	1.368	56	1.629
6	1.043	23	1.188	40	1.381	57	1.648
7	1.051	24	1.198	41	1.394	58	1.666
8	1.058	25	1.208	42	1.408	59	1.686
9	1.066	26	1.218	43	1.421	60	1.707
10	1.074	27	1.229	44	1.436	61	1.726
11	1.082	28	1.239	45	1.450	62	1.747
12	1.090	29	1.250	46	1.465	63	1.768
13	1.098	30	1.261	47	1.479	64	1.790
14	1.107	31	1.272	48	1.495	65	1.813
15	1.115	32	1.283	49	1.510	66	1.835
16	1.124	33	1.295	50	1.526		



SEVERAL INDICATED METHODS OF DETERMINING POLARITY

A shows the use of pole-finding paper, which denotes polarity by color; B illustrates the use of a potato to determine polarity; C is a glass tube filled with liquid, which is discolored by the action of the current; D is a breaker filled with acidified water, the negative pole having the most bubbles around it; E is a miniature storage battery, one of the plates of which becomes discolored when in contact with positive pole

CHART NO. 204-A—Electrolyte Tester. A Scale Reading in Baume and Specific Gravity. Polarity Testing: Finding the Positive and Negative Terminal of Electric Wires for Charging.

If after the battery has been fully charged, the gravity again falls to 1.250 or less, it indicates there is trouble somewhere in the system which must be located and corrected, and battery should be charged from an outside source. (see also index for "cadmium tests.")

The specific gravity readings of all cells of a battery should normally rise and fall together, as all cells of a battery as used with most systems are connected in series so that the charging and discharging current passes through all alike. (see also "cadmium tests" and pages 410, 416.)

If the hydrometer reading of one cell should be considerably lower than the readings of the other cells in the battery, and if this difference should increase from week to week, it is an indication of trouble in that cell.

The trouble may be due to a short circuit (page 456), causing the cell to discharge itself, or it may be due to a leaking jar, as a slight leak will allow electrolyte to escape, and if not noticed, the addition of water to replace its loss will lower the gravity.

A short circuited or leaking cell must be attended to at once (pages 478-456).

Thermometer used in connection with the hydrometer is very necessary as the sp. gr. readings are indicated at 70° F.; above or below this temperature the readings are not correct. See "Thermometer, its purpase," pages 447, 449, 451.

See page 457, locating battery troubles with a hydrometer, see also page 421 and 422.

**To Tell When a Battery Needs Recharging.

On systems where a storage battery is kept charged by a generator run from the engine the system is supposed to be automatic and the indications would be a **weak starting motor, or dim lights.** The battery, however, in this case ought not be allowed to become weak.

By testing with a hydrometer as per chart 204 the condition of battery can always be ascertained, and it is advisable to test at least once a **week.**

It will be well therefore before adding **distilled** water to the battery, to test the electrolyte with the hydrometer.

It must be borne in mind that a battery used for a starting motor is practically discharged, or so low that it will not properly operate the starter, when specific gravity is 1.225. Whereas when used only for lights or ignition, it will supply current down to 1.150 sp. gr.

As you **charge** your battery, the hydrometer readings will **increase** with the state or degree of charge.

As you **discharge** your battery, the readings will **diminish** with the degree of discharge.

Therefore it is advisable to recharge from an outside source or run with fewer lights, and run more in the day time with lights off, when the hydrometer reading is as low as 1.225. See chart 204.

*The Volt Meter for Testing Battery.

A battery should never be discharged completely. As stated, when testing with a hydrometer 1.150 is the limit for batteries used for ignition and lights and 1.225 for starting motors.

A volt meter can also be used to test the cells, but bear in mind the test is not practical unless it is made when battery is discharging or charging. See page 414, 416, 410, and note how meter is connected to test one or all cells.

Each cell should never show less than 1.8 volts per cell or 5.4 volts for a 6 volt battery (readings taken when battery is discharging or charging). The normal voltage of the battery is 2.2 volts per cell when doing no work, which is, if the electrolyte be 1.250 sp. gr., usually lowered to about 2.1 volts, due to internal resistance.

The storage battery unless worked below 1.8 volts, has a recuperative power of raising from 1.8 volts to the normal 2.1 or 2.2 volts within a few minutes after the discharge current has been discontinued. This act has often led many users astray as to their opinion of the condition of their cells.

For instance, suppose one to be out with his car, and the spark is not sufficiently strong to give satisfactory ignition of the gases; he stops to locate the defect. Usually the first thought is, are the batteries right? The voltmeter is taken and put to the cells and because they read 2.0 to 2.1 they are deemed all good.

Whereas, if the reading had been taken while battery was discharging, the volt meter would probably have read 1.8 volt or perhaps less per cell. In this way it often occurs, that much time has been lost in going over the car looking for the defect, while all the time it has been the batteries which have innocently showed 2.0 volts, because they were standing idle.

The voltmeter can also be used to determine the positive and negative pole of battery. Touch voltmeter terminals instantaneously across the circuit. If needle runs upward in the normal direction on the scale, voltmeter is properly connected and the wire which touches the positive meter terminal is thus identified as positive. If the connections were reversed, the needle would kick off the scale, indicating that the positive terminal of the voltmeter should be connected to the other wire. Note—never connect an ammeter to the terminals of a battery, unless a shunt is used. See chart 191.

---

*Note—Many repair shops have volt meters per pages 414, 416, 410. When a charged battery is discharging it will give say about 2 volts per cell until 50% of its capacity is used, then gradually drop to 1.8 volt per cell. Therefore a meter reading in one-tenth part of a volt will give accurate test if battery is on discharge, telling the condition between the 2 volt drop and 1.8 drop in fractions of a volt. See pages 416, 410, also index for "Cadmium Tests."

**Also see pages 410, 416, 414, 421 and 422.

The specific gravity test with a hydrometer is the only safe way. Provide your self with a hydrometer to enable you to test the gravity of your electrolyte periodically, and you will avoid a great **deal of trouble.** (See chart 204A.)

It may be said that the condition of **the** specific gravity is the pulse of **the cell, and** certainly it is the one means **of ascertaining** the exact condition of **health of the cell** or battery.

*Care of a Storage Battery.

The care of a battery in service or where there is a generator on the car to recharge it, is summed up in the four following rules, which, if observed with reasonable care will result in the best service being obtained:

1—Add nothing but pure water to the cells and do it often enough to keep the plates covered.

2—Take frequent hydrometer readings.

3—Give the battery a special charge whenever the hydrometer readings show it to be necessary.

4—Keep the filling plugs and connections tight, and the battery clean.

Adding Water.

Water must be added often enough to keep the plates covered. If the plates are exposed for any length of time, they may be seriously damaged.

The length of time a battery can go without the addition of water will depend upon the season of the year, water being required more frequently in summer than in winter.

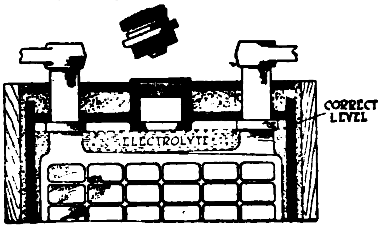


Fig. 14—Section of cell, showing correct level of electrolyte.

The best plan is to make it an invariable rule to remove the filling plugs once each week and add water if level of electrolyte is below bottom of filling tube.

Never bring an open flame, such as a match or candle, near the battery.

Always add the water regularly, though the battery may seem to work all right without it.

In freezing weather, when necessary to add water, always do it just before running the engine.

If temperature is extremely low, start the engine so that the battery is charging before adding water.

The reason for this is that water being lighter than electrolyte will remain on the surface and will freeze in cold weather. If the engine is run, however, the gassing, due to the charging current, will thoroughly mix the water with the electrolyte; also the motion of the car when running will have a similar effect. Thoroughly mixed electrolyte will not freeze solid, except at very low temperatures.

The reason why the solution (electrolyte) falls below the top of the plates, is due to evaporation. Water evaporates when battery is in service, the **acid does not, therefore** it will be necessary to replace the **water** —but don't add too little and don't add **too** much. Many a case of apparent **leak has** been blamed to an over indulgence **of water.**

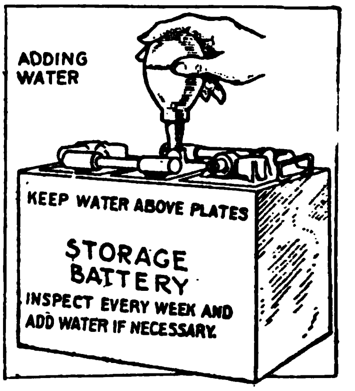
You will have to replace evaporation **but** do not add enough water to **any cell to** raise the electrolyte above the indicated level.

Electrolyte level. Note that for **each** battery there is **a** well defined level, up **to,** or nearly to which, you should endeavor **to** keep the surface of your **electrolyte, but** above which you must never **raise the level** of the solution when you add water **to your** battery. In the U. S. L. type EDC **battery** as an example, the level is **1 inch above** plate tops. In the type EL the level **is ⅝** inch. In all other types of U. S. L. batteries the electrolyte level is **½ inch above** the plates.

Not only should the electrolyte level **be** at the same height in all cells, **but there should be the same amount of acid in the electrolyte in each cell.** Therefore **always** restore the electrolyte from **syringe when** testing, back into cell from which it **was** taken.

Each time water is added to the cells, first take a hydrometer reading of each cell to see whether all cells are equally healthy. No cell can live unto itself—if it **goes** wrong it affects the others.

How to add water: Remove filling **plugs** by turning to the left, and if level **of electrolyte** is found to be below bottom **of filling** tube (fig. 1, chart 203A), **add water by** means of the hydrometer syringe or **a very** small pitcher until the level **begins to rise** in the tube.



---

*Also see pages 421, 422, 416, 410.

After adding water be sure to replace filling plugs and tighten by turning to the right. **If filling plugs are not tightened, the electrolyte will flood out of the battery and cause damage.** Also wipe off the top of battery.

Kind of water: The water used must be of reasonable purity, as the use of impure water, if persisted in, will injure the plates. Distilled water, melted artificial ice, or rain water collected in clean receptacles is recommended.

Water collected in rain barrels from metal roofs, would contain a trace of the mineral —therefore avoid same.

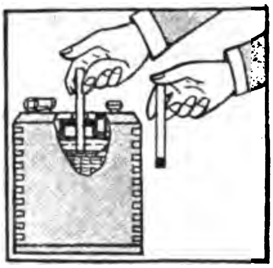
Nothing but pure water must be put into the cells. If acid of any kind, alcohol, or in fact anything but water, is added to the cells, it will result in very serious injury to the plates and may ruin them.

There being no loss of acid, it is never necessary during normal service, to add any acid to a battery.

If electrolyte has been spilled from the battery by accident, the loss may be replaced with electrolyte, see page 473.

Finding Level of Electrolyte.

Unscrew the vent from its well, push a glass tube with both ends open, straight down, as shown above, through the well and against the tops of the plates. Then close top end of tube with your thumb and remove the tube with the top end still closed. The height of liquid in the tube equals the height of the electrolyte level above the tops of the plates. Be sure to restore the electrolyte to the cell from which it was taken. If you persistently take electrolyte from one cell and put it into another you will gradually get your cells unbalanced. Be sure to test levels in all cells.



Take frequent hydrometer readings, for they show whether the battery is receiving sufficient charge.

When the battery is used in connection with a charging generator system, the system is so designed and adjusted that the amount of charging current received by the battery from the charging generator (dynamo) should about compensate for the discharge current used when starting the engine or when lighting the lamps from the battery. At medium or high speeds, the current for lamps does not come from the battery, but from the dynamo.

It sometimes happens, due to unusual conditions, such as excessive use of lamps, especially when car is driven at low speed, that the battery will not receive enough charge from the dynamo and will become more or less discharged, which will be indicated by lowered hydrometer readings (pages 421 and 422).

When battery is used alone (without generator), the hydrometer readings will likewise indicate the state of discharge of the battery and **when it is necessary for it to be charged.**

*Care of Battery With a Generator on the Car.

Care of battery case: If water or electrolyte is spilled upon the battery or in the compartment, wipe dry with waste. If electrolyte is present in any quantity, use waste moistened with weak ammonia in order to neutralize the acid in the electrolyte. Do not allow electrolyte to collect upon the woodwork as it will cause deterioration.

Once a week, when adding water, inspect all the battery connections and make sure that they are tight and clean. A **loose** or **dirty connection** may cause trouble when least expected.

Care of connections: If signs of corrosion of any brass or copper parts should appear, clean the parts thoroughly with weak ammonia and apply vaseline.

Connections throughout the system must be examined periodically and kept tight and clean. Sometimes a connection even if tight, will give trouble, due to foreign matter such as paint or varnish on the contact surfaces. This must be removed with a file or sand paper. **The connections to the generator and the grounding connections to the frame of the car must not be neglected.**

*Care of Battery Without a Generator on the Car.

If the battery is used alone (without generator) to supply current for lights or ignition, it will not be necessary to add water except when the battery is removed from the car for charging.

Frequent hydrometer readings should be taken, however, and when the gravity falls below 1.200, the battery should be removed from the car and charged.

Do not allow the battery to discharge until completely exhausted, as shown by gravity falling to 1.150 or thereabout and by lamps burning dimly or voltage falling below 1.8 volts per cell.

Give the battery a charge at least once every two months whether the hydrometer readings show this to be necessary or not.

Battery Out of Service.

If the battery is not to be used for a considerable period, say the winter months or longer, it should be taken where it can be charged once every month and the plates kept covered by regularly adding **distilled** water. If charging is not possible, do not attempt to remove the electrolyte, but send the battery to the nearest place which has facilities for the periodic charge.

If this cannot be done, add distilled water to each cell until solution reaches inside cover, then charge to full voltage and store in a dry place. Inspect battery, once a month, refill with pure distilled water to make up for evaporation and give it a refreshing charge at the finish rate.

It should be fully recharged before storing: also recharged when put into service again. Another point, **don't forget to disconnect battery wires,** if left standing for a long period of time, in order to not lose its charge through a slight leak.

If batteries are to be idle for a continued long period—fully charge, then remove electrolyte and put in distilled water.

When battery is put into use again remove water, put in 1.300 sp. gr. electrolyte and recharge. Just as soon as the electrolyte is put into battery under these conditions the plates will absorb the acid from the solution and will drop in sp. gr. to as low as 1.100 but just as soon as battery is put on charge and fully charged it will rise to 1.300.

---

*See also pages 456, 458 and 422.

connect an ammeter to the terminals of a battery, unless a shunt is used. See chart 191.

The specific gravity test with a hydrometer is the only safe way. Provide your self with a hydrometer to enable you to test the gravity of your electrolyte periodically, **and you will avoid a great deal of trouble.** (See chart 204A.)

It may be said that the condition of the specific gravity is the pulse of the cell, and certainly it is the one means of **ascertaining the exact condition of health of the cell** or battery.

*Care of a Storage Battery.

The care of a battery in service or where there is a generator on the car to recharge it, is summed up in the four following rules, which, if observed with reasonable care will result in the best service being obtained:

1—Add nothing but pure water to the cells and do it often enough to keep the plates covered.

2—Take frequent hydrometer readings.

3—Give the battery a special charge whenever the hydrometer readings show it to be necessary.

4—Keep the filling plugs and connections tight, and the battery clean.

Adding Water.

Water must be added often enough to keep the plates covered. If the plates are exposed for any length of time, they may be seriously damaged.

The length of time a battery can go without the addition of water will depend upon the season of the year, water being required more frequently in summer than in winter.

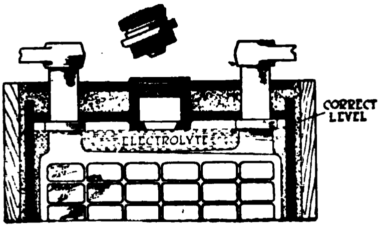


Fig. 14—Section of cell, showing correct level of electrolyte.

The best plan is to make it an invariable rule to remove the filling plugs once each week and add water if level of electrolyte is below bottom of filling tube.

Never bring an open flame, such as a match or candle, near the battery.

Always add the water regularly, though the battery may seem to work all right without it.

In freezing weather, when necessary to add water, always do it just before running the engine.

If temperature is extremely low, start the engine so that the battery is charging before adding water.

The reason for this is that water being lighter than electrolyte will remain on the surface and will freeze in cold weather. If the engine is run, however, the gassing, due to the charging current, will thoroughly mix the water with the electrolyte; also the motion of the car when running will have a similar effect. Thoroughly mixed electrolyte will not freeze solid, except at very low temperatures.

The reason why the solution (electrolyte) falls below the top of the plates, is due to evaporation. Water evaporates when battery is in service, the **acid does not,** therefore it will be necessary to replace the **water** —but don't add too little and don't add too much. Many a case of apparent **leak has** been blamed to an over indulgence of **water.**

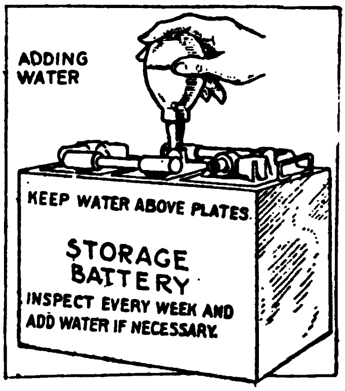
You will have to replace evaporation but do not add enough water to any cell to raise the electrolyte above the indicated level.

Electrolyte level. Note that for each battery there is a well defined level, up to, or nearly to which, you should endeavor to keep the surface of your electrolyte, but above which you must never raise the level of the solution when you add water to your battery. In the U. S. L. type EDC battery as an example, the level is 1 inch above plate tops. In the type EL the level is ⅝ inch. In all other types of U. S. L. batteries the electrolyte level is ½ inch above the plates.

Not only should the electrolyte level be at the same height in all cells, **but there should be the same amount of acid in the electrolyte in each cell.** Therefore **always** restore the electrolyte from syringe when testing, back into cell from which it was taken.

Each time water is added to the cells, first take a hydrometer reading of each cell to see whether all cells are equally healthy. No cell can live unto itself—if it goes wrong it affects the others.

How to add water: Remove filling plugs by turning to the left, and if level of electrolyte is found to be below bottom of filling tube (fig. 1, chart 203A), add **water** by means of the hydrometer syringe or a very small pitcher until the level begins to rise in the tube.



---

*Also see pages 421, 422, 416, 410.

Overheating caused by overcharging may occur if the regulation goes wrong and permits the generator to deliver excessive current.

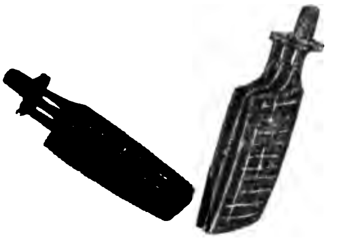


Fig. 4. A buckled plate.

It would be well occasionally to feel your battery, particularly the lead links and cover, after a long, hard drive. Should you suspect overheating, remove the vents from the cells and insert a thermometer, of the type made for insertion into liquids, into the electrolyte of each cell. The battery temperature should never be allowed to exceed 110° F. Garage men who make a practice of charging batteries in their plant should enforce this rule rigidly.

Overheating should be avoided, because it expedites evaporation of water from the electrolyte, causes deterioration of plates and separators, and tends to buckle the plates. Overheating of one half the battery should be guarded against especially in "double voltage" systems.‡

*Diagnosing Troubles Due to the Battery.

If trouble should develop, as shown by the engine not cranking properly, lights burning dimly or "missing" of the engine when battery is used for ignition, look for the cause as indicated below.

(1) Make sure that all †**connections are tight** and that all contacts are clean.

(2) **Take a hydrometer reading** of each cell. If battery is found to be exhausted (gravity 1.150 or thereabout), give a special charge, outside source.

(3) If after having been fully charged, the battery is soon exhausted again, there is trouble somewhere else in the system, which should be located and corrected.

(4) The wiring may have become grounded to the frame of the car, and cause a leakage of current which in time may completely discharge the battery.

This may be tested for as follows: At night or in dark garage, turn on all the lamp switches, but remove the bulbs from the sockets and disconnect the battery ground wire at the ground plate. Then strike the bare end or terminal of the ground wire against the ground plate; if sparks are noticed, there is a ground in the wiring, which should be looked for and removed. (See fig. 6, page 413.

(5) If a broken jar or short circuited cell is indicated (gravity considerably lower than in other cells), have the battery repaired.

When lamps burn dimly, turn on all the lamps and read the voltage with a low reading portable volt meter of each cell or of the battery—see pages 416, 410.

If the voltage per cell is 2 volts or thereabout, the trouble is in the connections.

If cell voltage is low (1.8 volts or lower), the trouble is in the battery. See pages 456, 416, 410.

When lamps burn brightly, but engine will not crank, notice when attempting to start engine whether lamps become very dim or go out; if they do, the trouble is in the battery.

If they continue to burn brightly, the trouble is in the motor or motor circuit.

Locating Battery Troubles with a Hydrometer.

A battery is said to be on open circuit when no proper circuit through which it could discharge is closed, as with a lighting or starting switch. Ability to maintain the specific gravity under such conditions, likewise means ability to hold the charge. The best way to test the battery in this respect is to insure a full charge as with a drive in the evening, to test all cells and make a note of the readings, and to again test the gravities with the hydrometer the next morning after, say 10 hours, have elapsed since charging. If all cells maintain the gravity uniformly well, under such conditions you may be sure that the battery is in excellent health.

Low gravity in all cells. If your starter occasionally fails to spin your engine, and if you confirm your suspicions that the battery lacks energy, by testing with hydrometer and finding the "gravity" low, say below 1.225 it may be that all the battery requires is an extra charge. You may have previously discharged your battery to so low a state that the normal generator output has not been sufficient to restore it. If failure due to low gravity recurs after this extra charge, you will know that your generator is failing to put enough current into the battery, and that the generating function must be tuned up. Or it may be that a short-circuit in the wiring is dissipating the battery energy.

Low gravity in one cell. Should you find the gravity low in any cell, say 50 points lower than in the others, regard that cell with suspicion. Hydromete the cells oftener to determine whether the difference in gravities of the cells is increasing. If the trouble increases, the cause undoubtedly is that a short-circuit is commencing. Some one of the following conditions must be the cause: separators wearing through, or "mud" accumulating in the bottom of the jar until it touches the plates, or a piece of metal has fallen into the cell and has bridged across the plates. Again, water containing certain minerals may have been put into the cell and these minerals have prevented the cell from holding its charge. The remedy is the same, whatever the cause. The element must be taken out and the cause removed. New separators should in almost every instance, be installed in all cells.

A broken jar is sometimes the cause of persistent low "gravity" in a cell. You can usually detect a broken jar from the fact that you will have to add water more frequently to its cell than to the others, to keep the plates covered. The electrolyte leaks through the crack in the jar and seeps out between the jar walls and sealing compound. The greater admixture of water to replace the electrolyte lost from such a cell, will naturally reduce that cell's "gravity."

---

*Also see pages 421 and 422. †**A common trouble** is one where connections of wire terminals to battery and ground connection to rame of car are not properly made—see page 421.

‡**Double voltage system means** where there are two different circuits to battery; using different voltages—see page 466.

We find, however, that 95 per cent of all cases of supposed leaks, are not leaks at all but are simply the result of adding too much water.

Sulphation and low gravity. If the battery has been properly attended to there has been no chance for sulphation. But, suppose you have owned a battery for some time and have just acquired virtuous battery habits, so that you can vouch for what has been going on in your battery. And suppose you observe that the gravity of a certain cell is persistently low, and that you have to add water too frequently to that cell to keep its plates covered. Mark that this by no means convicts the jar. You may'hav3 previously been inattentive, or at least partial with the water ministration. As a result the tops of that cell's plates may have been left exposed to the air for a spell, and so the plate tops may have become sulphated, and the disease has proceeded downward so as to affect the plates throughout. Then, if this evil had progressed far enough, the cell would not respond to charging and the "gravity" would not rise. The cell would become unduly hot during charge and would hasten the evaporation of water.

1.150 or lower. With "gravity" as low as this, the battery cannot be depended upon even to operate the lights.

Gravity too low to read. Hydrometer markings generally run as low as 1.150. Batteries may be found with gravities too low to be measured witn the ordinary hydrometer, so that you cannot fully diagnose the battery with this instrument alone. These are extreme cases and require an expert's attention. Possibly all they require is a thorough charge, but the special conditions of the necessary charge must be observed. Should there be sulphation—and there is likely to be if the battery has stood long in a state of low "gravity"— the rate of charge secured in the automobile would undoubtedly overheat and buckle the plates and so injure both plates and separators and cause an early finish of the battery's career.

Constantly high "gravity." While we have indicated 1.285 as the proper top mark for full charge, a reading of 1.800 of itself need cause no alarm. However, if a few hydrometer tests, and a study of your driving habits show you that you are regularly charging your battery for considerable periods after the "gravity" reaches 1.285, it is up to you to do something to abbreviate your charging, for your battery is getting more than enough, and you are daily shortening its normal life. Have the generator output reduced. And to clinch the improvement have a touring switch installed see page 427.)

Excessive gravity. Gravity above 1.300 is certainly abnormal and points the accusing finger unerringly to the man who "doped" the battery with excess acid. Prompt reduction of the acid proportion is needed to save the battery's life.

*A Digest of Battery Troubles; Cause and Remedy.

Liquid low in one cell.—Cause; cracked or broken jar.—Remedy; new jar.

Electrolyte gravity won't rise.—Cause; sulphated.—Remedy; see page 461.

Overheating.—Cause; liquid low or charged too rapidly.—Remedy; refill with water and inspect regularly, or alter generator regulation.

Electrolyte leaking at top.—Cause; solution too high.—Remedy; draw out a quantity with syringe.

Battery constantly low.—Cause; under-charging.—Remedy; examine generator brushes, if o.k. increase charging rate and have battery charged from an outside source.

Buckled plates.—Cause; overheating.—Remedy; charge at lower rate—keep liquid in cell—keep temperature below 110. deg.

Battery exhausts quickly while idle.—Cause; short circuits.—Remedy; go over wiring and renew insulation.

Frozen battery.—Cause; discharged in cold weather.—Remedy; damage may be irreparable—may try reforming charge for crystalization.

Rotting insulators.—Cause; impure water—too much acid.—Remedy; use distilled water only or melted artificial ice.**

Battery won't take charge.—Cause; connectors loose—see crystallized plates.—Remedy resolder connectors and plate holders.

Terminals corroded.—Cause; acid leak through vents.—Remedy clean with ammonia or washing soda.

Jars break rapidly.—Cause; battery not fastened down.—Remedy; see that proper cleats and bolts are fitted.

Separators punctured.—Cause; overheating.—Remedy; renew separator and keep battery filled.

Lights rise and fall.—Cause; battery low.—Remedy; recharge outside or by long run at 20 m.p.h.

Battery won't operate after storage.—Cause; not maintained during storage.—Remedy should have been kept charged—probably cannot be repaired owing to disintegration.

Lamps dim although electrolyte at high level.—Cause; specific gravity too low.—Remedy; bring specific gravity up to 1.275 by charging—see that generator gives 20 per cent more current than lamp consumption.

Electrolyte down to 1.100.—Cause; overdischarge.—Remedy; give reforming charge at 3 amps, until up to maximum density.

One cell dead.—Cause; insulation destroyed.—Remedy; watch overheating and overcharging—keep electrolyte up.

Battery dead from usage.—Cause; using without restoring.—Remedy; charge for 24 hr. at rate marked on battery or until electrolyte reaches 1.275.

Large sediment deposit.—Cause; active material dropping.—Remedy; take battery to service station at once, as material has become loosened.

Storage Battery Pointers.

(1) **Learn to prepare the electrolyte.** Use a large earthen crock or lead vessel with burnt seams. One part of chemically pure concentrated sulphuric acid, is mixed with several parts of water, the proportion of water varying with the type of cell. (see pages 448 and 451.)

(2) **Prepared electrolyte may be purchased** if desired—see page 478.

(3) **Always pour the acid into the water, never the reverse.**

(4) **Use pure water,** either distilled or rain water.

(5) **Allow the electrolyte** to cool before placing in the cells. The specific gravity should be 1.200 or 25 degrees Baume. Add distilled water if a higher reading is obtained.

(6) **Grids should always be at least ½ inch** below the surface of the solution.

(7) **Woolen clothing is little affected** by acid

(8) **Ammonia immediately applied to a splash of acid on the clothes, neutralizes** the acid and prevents a hole being burnt in the material.

(9) **In case a bit of acid splashes into the eye,** wash well with warm water and put into the eye a drop of olive oil.

(10) **Avoid the use of an open flame in a room where a storage battery is being charged,** or in which it has been left for some time, as an explosive mixture of air and hydrogen may be formed.

(11) **Storage batteries are rated in ampere-hour,** this being based on the steady current the battery will discharge. A battery that will discharge at five amperes for eight hours without

****Distilled water:** Artificial ice is not always made of distilled water. Rain water can be used if it does not come from a metal roof or where mineral substances will get into it. Drug stores have small distillers which consist of a glass tube in which water is boiled and the steam condensed into distilled water. Filtered water will not do.

*Also see pages 422-423, 416, 410.

the voltage falling below 1.75 is rated as a 40-ampere-hour battery. This does not mean that 40 amperes would be the output of the battery if discharged in one hour. The ampere-hour capacity decreases with the increase in current output.

(12) **The current in charging should be kept within the maker's specified limit.** One authority advises for rapid charging covering a period of three hours, 50 per cent, 33 per cent and 16 two-thirds per cent of the total current for each consecutive hour.

(13) **The e. m. f. of the charging current at starting the charge,** should be about five per cent higher than the normal e. m. f. of the battery. After a few minutes this voltage may be 10 or 15 per cent higher than the normal battery e. m. f. However, the battery is kept in the best condition by using a constant charging current and if necessary to maintain this, the voltage may be raised to 25 per cent higher than the normal battery voltage.

(14 **Be sure the positive pole of the charging mains is connected to the positive side of the battery.**

(15) **To determine the polarity** hold the two wires in a glass of acidulated water or electrolyte, keeping them at least ½ in. apart. Gas will collect most at the negative lead.

(16) **A cell is fully charged:** (a) If, with a constant current, the voltage and specific gravity do not change in one hour. (b) When the plates decidedly increase the quantity of gas given off. (c) When the specific gravity measures 1.275, and the voltage from 2.5 to 2.7. (d) When the negative plate assumes a light gray color and the positive plate turns a dark brown.

(17) **Never adopt the method of putting a wire across the positive and negative terminals, to see if there is any "spark."** It is almost a dead short-circuit, and if the cell be of a small capacity of, say 30 ampere-hour, and the wire No. 16 copper, the current may be anything from 30 to 100 amperes for a fraction of time, which, when calculated, is a very appreciable amount of the total capacity, if only for a second of time duration. It is also very detrimental to the cell, assisting the disintegration of the plates or active material thereon.

(18) **Lead cells** should not be discharged below 1.7 volts.

(19) **Excessive boiling** will loosen the active material.

(20) **If the cells are hot while charging,** reduce the charging current.

(21) **If a battery is not in use,** give it a short charge once a month.

(22) **If white sulphate is formed on the grids,** it may be reduced by charging at a high rate for a few hours and overcharging at a low rate for two or three days.

(23) **Continued sulphating will buckle the plates,** as will also too rapid discharging.

(24) **A cell that has been short-circuited, should be disconnected from the battery** and charged and discharged several times separately.

(25) **Makers furnish directions for keeping batteries when not in use.** One way to do this is to charge the battery fully, then siphon the electrolyte out of the jars, to be kept until used again. The plates must then be removed and stored.

(26) **Never allow the cells to stand in a discharged condition,** as it becomes very difficult to get them properly charged if left standing any length of time, unless great care is taken during the succeeding charge.

(27) **If the terminals begin to corrode,** use vaseline.

(28) **Voltage readings** should be taken only when charging or discharging.

(29) **Do not let the battery get too warm;** its temperature should never exceed 100° F.

(30) **Use only distilled water to replace losses** from evaporation. Add acid only in special cases.

(31) **Each time you charge, bring the gravity** up to maximum, or charge until it has remained constant, for at least one hour in every cell.

(32) **When charging the battery, put in at least 20 per cent more current (ampere' hours)** than is taken out, and at every third charge give it a 50 per cent over-charge, at the finish rate for the general good of the battery.

(33) **Voltage readings are only approximate** Gravity readings give correct indications.

(34) **Keep the box containing the battery perfectly dry.** If any acid is spilled into the box, wipe it off carefully with a piece of waste dipped in ammonia water.

(35) **When charging at the finish rate or 24-hour rate,** leave battery on until bubbles begin to rise in the electrolyte, then for at least one hour longer.

(36) **Never add acid or electrolyte to the cells except to replace loss from spilling.**

(37) **In cases where the specific gravity will not show any rise** during or at the end of its charge, it indicates a short circuit, and the cell has not received its charge.

(38) **In cases where the specific gravity comes up to 1.250 at the end of its charge, but falls** to a lower figure during a period of idleness or standing for say twenty-four to forty-eight hours, this also indicates a short circuit, or else local action (or internal discharge), due to contamination of the electrolyte by some impurity.

**Charging a Battery.

The charge must always be given from a "direct" current circuit (never an alternating, unless a rectifier is used), and great care taken to **connect the positive wire to the positive terminal of the battery** either directly or through the *resistance which is usually necessary; the negative wire must then, of course, be connected to the negative terminal of the battery. **If connected in the reverse direction,** very serious injury to the battery will result. To test for polarity, see chart 204-A.

Reversed charge: Should a reversal occur, put the battery on charge at the 24-hour rate and leave it on for several days. Do not take it off until its voltage and gravity both have reached a maximum, with battery at normal temperature, 70 degrees F.

Charging rate. Start the charge at a rate equal to the normal charging rate (start) or lower, as shown in the tables and continue the charge until the cells gas freely. This will ordinarily take about six hours. Then continue the charge for six hours at the normal rate (finish), see tables, chart 205-D.

A battery charge is complete when, with charging current flowing at the finish rate given in the tables, all cells are gassing (bubbling) freely and evenly and the gravity of all cells have shown no further rise during one hour.

The 24-hour rate is the one used for charging through the night, and cells charging at this rate may be left on continuously.

If you have no voltmeter nor hydrometer, it is possible to determine when the battery is fully charged by observing when gas bubbles begin to rise from the solution while battery is charging at the 24-hour rate.

*See page 474. **See also, page 470 for **charging a repaired battery.**

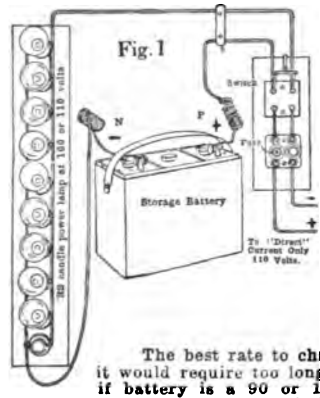


Fig. 1
32 candle power lamp at 100 or 110 volts
Switch
Fuse
N
P
Storage Battery
To "Direct" Current Only 110 Volts.

Charging Storage Batteries from a *110 Volt Direct Current Circuit Using Lamps.

A storage battery can be charged from a 110, 220 or 500 volt direct current circuit by merely placing lamps into circuit, so that the current in passing through the lamps must pass **through the** battery. The lamp method is not an efficient method. **Some of the** small garages utilize the lamps for lighting the garage—see **page 465.**

The amount of current or amperes, depends upon the **candle power** or watt capacity of the lamp and the method of connection.

A 32 c. p. 110 volt, carbon filament lamp will pass approximately 1 ampere and is a 100 watt lamp. Watts are found by multiplying the voltage of the circuit (100 volts used instead of 110, which is near enough in this instance) **by the ampere capacity, as 100** volts × 1 amp. = 100 watts.

A 16 c. p. 110 volt carbon filament lamp will pass ½ ampere and is a 50 watt lamp.

To Charge a Single Battery.

The best rate to **charge any battery is at a slow rate** for a long time, but in many **instances** it would require too long a time. About a 6 ampere rate would be best for small **batteries, but** if battery is a 90 or 100 ampere-hour "starting and lighting" battery, we **will use say, 10** amperes, or 10, 32 c. p. 110 volt lamps, per fig. 1 (only 9 lamps shown). Lamps are connected in "parallel," or across the line and battery is connected in "series" with the bank of lamps.

A high rate will charge the battery quicker but battery heats up quicker, which is injurious **to battery.** In fact, in charging any battery the temperature should not be above 110 degrees and if it **rises to** this point the charge is too heavy and should be cut down. **To find the polarity** of charging **wires and battery,** see page 452.

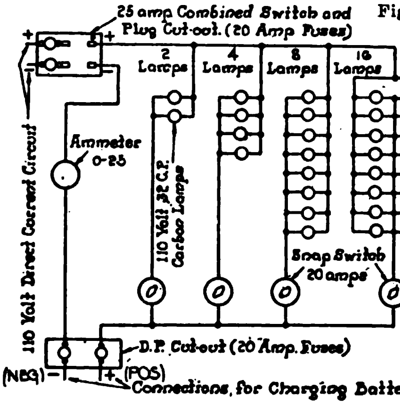

25 amp Combined Switch and Plug Cut-out. (20 Amp Fuses)
+
+
2 Lamps
4 Lamps
8 Lamps
16 Lamps
Ammeter 0-25
110 Volt 32 C.P. Carbon Lamps
Snap Switch 20 amps
110 Volt Direct Current Circuit
D.P. Cut-out (20 Amp. Fuses)
(NEG) −
+ (POS)
Connections, for Charging Batteries

Fig. 37.

Charging 1 to 11 Batteries.

Place batteries in "series" per fig. 4. page 462. Then use the number of lamps per table below. We are assuming that charging circuit is a 110 volt direct.

Number of Batteries	No. of 32 c. p. 110 v. Lamps at "start" and amp's.	No. Lamps for "finish" rate	No. Lamps for "24 hour" rate
1	10L—10a	3L.	5L.
2	10L— $9\frac{1}{2}$a	3L.	5L.
3	11L— $9\frac{7}{10}$a	3L.	5L.
4	12L— $9\frac{5}{10}$a	4L.	6L.
5	13L— $9\frac{3}{8}$a	4L.	6L.
6	15L—$10\frac{2}{10}$a	4L.	7L.
7	17L—$10\frac{1}{10}$a	5L.	8L.
8	19L—$10\frac{3}{8}$a	6L.	9L.
9	21L— $9\frac{9}{10}$a	6L.	10L.
10	25L—10a	8L.	12L.
11	30L— $9\frac{8}{10}$a	9L.	15L.

L designates **lamps** in circuit and a, **amperes** passing to battery.

It will be observed, that to charge more than one battery, more lamps are used in order to obtain the **same** amperage rate of charge, or nearly the same. This is due to the fact that as each battery is connected in series with another, the battery voltage is **increased.**

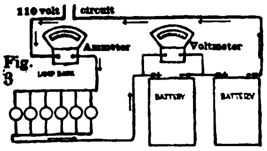


Fig. 3

When charging several batteries, the practice is to charge at 6 amperes during the day and 3 amperes at night. **This permits watching in day** and avoids overheating at night.

Above table is figured for a discharged 90 to 100 ampere-hour **6 volt** starting and lighting battery (see page 467). **If smaller batteries are on the line,** or if some **are partially discharged,** then charge **at 24 hour** rate until smaller ones or partially discharged ones are charged, **then** remove them.

30 Ampere, Lamp Charging Outfit.

Fig. 37 outfit has a base of hard wood and No. 12 wire is used. Various charging rates can be had by switching on banks of lamps instead of unscrewing lamps. Note 2, 4, 8 or 16 lamps can be used singly, or all together which would make 30 **amperes** total. Each 32 c. p. 110 volt lamp gives 1 ampere.

To obtain 20 amperes, switch on the 4 and 16 bank; **10 amperes,** switch on the 8 and 2 bank; **5 amperes,** put 2, 16 c. p. ½ ampere lamps in 2 bank, which would give 1 amp., and use this with the 4 **bank.**

Ammeter indicates quantity of current in amperes, passing to battery. It can be connected in series per figs. 37 and 3. An ordinary dash type can be used if rate of charge is not over capacity of **meter.** If in connecting meter, hand points wrong direction, reverse the connections to meter.

Testing Battery For Charge.

The battery requires careful watching. A volt-meter or hydrometer or both can be used for testing.

A volt-meter is connected "across the line" per **fig. 3, which is shown testing the entire battery.** It is best to test **each cell,** per A, page 416.

If volt-meter reads 2.4 to 2.5 volts per cell when charging, decrease number of lamps to 2½ to 3 amperes. Charge for about 5 hours more and if still reads 2.5 volts, charging is complete—see **also pages** 458, 459.

A hydrometer is used most for testing during charge. If on a test the specific gravity (s. g.) shows 1275 to 1300 and battery "gases" freely, then reduce charge to 2½ or 3 amperes for say 5 hours more, being sure temperature does not rise over 110 degrees. If s. g. does not change, battery is charged. See also page 459. The 2½ amperes can be obtained by using 2—32 c. p. lamps and 1—16 c. p. 110 volt lamp.

On some old batteries the s. g. may not rise above 1250, then it is a matter of using it and recharging again soon.

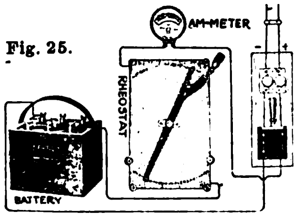


Fig. 25.

A Rheostat

Shown in fig. 25 is a wire resistance, mounted on the back of a slate base. The resistance is iron wire, German silver or other kind of resistance wire which can be placed in the circuit, more or less amount, by movement of lever. See also page 464 and page 474.

CHART NO. 205—Charging Storage Batteries with Direct Current from a Lighting Circuit, using Electric Lamps. A Rheostat. *See page 465 for charging from 220 and 500 volt circuit.

Hurrying a charge; this is not recommended, but when unavoidable proceed as follows:

Put the battery on **double the "start" rate** given for your battery in the table of rates, chart 205-D.

Lighting batteries can be placed on the line with batteries capable of taking a charging rate higher than that usually given to sparking batteries, and at all times the batteries should be left on until gravity has reached its maximum and remained stationary at this maximum for at least an hour.

Charging Rates.

Commence the charge at the current rate given under "start" Chart 205-D. Be sure that the rate is correct for the particular type of battery. Continue to charge at the maximum rate until the cells begin to gas or bubble freely, at which time the voltage will be approximately 2.5 volts per cell (7.5 volts for a 6-volt battery). When one or both of these conditions are obtained, reduce the charging current to the value giving under "finish," chart 205-D by unscrewing the proper number of lamps (if charging as per chart 205-), and continue to charge at this rate until the cells again gas freely, and the specific gravity of the electrolyte ceases to rise, as indicated by successive half-hour readings taken after the cells begin to gas.

At the end of charge the voltage will be approximately 2.5 volts per cell with the current flowing at the minimum rate, but on a new battery this voltage will be greater, reaching as high as 2.65 volts per cell.

The specific gravity of the electrolyte at the end of charge should be at a maximum between the value 1.275 and 1.285. Correct all specific gravity readings for temperature as described under "specific gravty," page 449. Make sure that the battery is full, but do not overcharge.

The temperature of the electrolyte should not be allowed to exceed 100° Fahrenheit during charge. If this temperature is exceeded, cool the battery by reducing the charging current, or by temporarily stopping the charge.

Charging Sulphated Batteries.

With the sulphated battery, the charging should begin at about a two or three-ampere rate and should not be allowed to raise beyond five or six amperes. A thermometer reading should be made every hour and the temperature of the solution should never be much over 100 degrees Fahrenheit. Never let it heat more than 110 degrees. When the cells begin to gas and give off bubbles, take the battery off of the charger and discharge the battery by connecting some lamps on it or some resistance across its terminals. Put in just enough lamps or resistance to draw a discharge current equal to 1/10 the ampere hour capacity; (if 80 ampere hour batteries, discharge at an 8-ampere rate) discharge the battery until each cell has a voltage of 1.6 to 1.7 volts while the battery is discharging. Repeat this process from two to three times and the sulphate will be well broken down and the battery in good condition. See also page 470.

Charging Circuit.

†**Resistance required:** If only one battery is to be charged from a **110 volt direct current circuit,** resistance must be used in series with the battery to reduce the voltage of the circuit to that of the battery.

The most convient resistances to use are 110 volt 32 candle power **carbon filament lamps,** connected in parallel with each other, and the combination in series with the battery (chart 205). With this arrangement each lamp will allow one ampere of charging current to pass through the battery, so that the number of lamps required will depend upon the charge rate of the battery (tables, chart 205-D).

For instance, for type XC-15, "Exide," charge rate 7 amperes, seven lamps will be required.

If 32 candle power lamps are not available, then double the number of 16 candle power lamps will be required as the current rating is only ½ of that of the 32 c. p. lamps.

If tungsten or other high efficiency lamps are used, more than twice as many will be required than if carbon filament lamps are used, owing to the lower current rating of the former.

If the battery is to be charged from a **220 volt circuit,** use two lamps in series in place of each of the lamps necessary when charging from 110 volts, and twice as many lamps, if they are not 220 volt lamps, see page 465.

If only a **500 volt circuit** is available, it is necessary to use five lamps in series in place of each of the lamps used when charging from 110 volts. (See fig. 15, chart 205-B).

*Charging Equipment for a Shop.

Install the necessary wiring, etc., so that batteries can be easily connected up and charged where they stand on the bench. Apply vaseline freely to battery terminals and exposed copper wire.

Lamp resistance: Thirty ordinary lamp sockets are mounted on a board and wired up to snap switches in groups containing two, four, eight and sixteen lamps respectively. A suitable main switch, fuse cutout, ammeter and terminal block complete the outfit.

Any good electrician will understand this layout and can make it up and install it quickly and at moderat expense.

With this equipment from one to twelve 3 cell batteries can be connected in series (the positive terminal of one connected to the negative terminal of the next and so on) and charged at one time.

The lamps which are in series with the batteries make it possible to regulate the current passing through the battery to the proper value. Different combinations of the

---

*Fig. 87, page 460. †See pages 474 for explanation of a "rheostat."—A complete charging plant including gasoline engine and dynamo—see page 824.

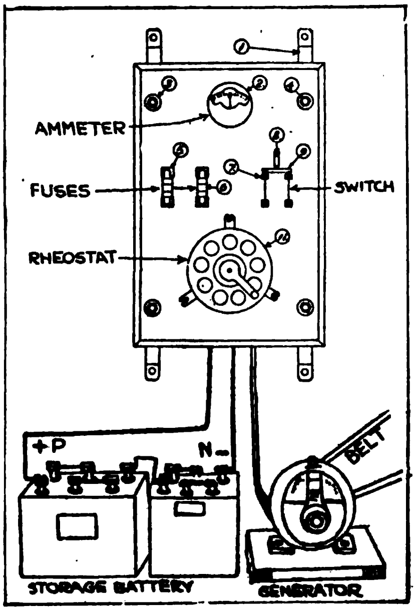


Fig. 1—Main belt driven generator.

The Main Belt Driven Generator.

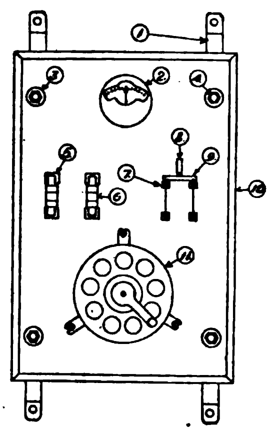


Fig. 2. Switch board.

Fig 1.—Battery c
ing outfit which c
operated from line
engine, or any
source. Speed of
mo is 2,000 r.p.m.
h. p. required to op
Will charge any ba
or combination of
teries not exceeding
volts. Any voltage:
12, 18, 24 or 30 volts.

Fig. 2 — Switch-b
of the Main ba
charging outfit.

(1) Brackets f
support; (2) d
reading ampere m
(3 & 4) bolts, (5 &
fuses; (7-8-9) d
pole single thr
switch; (10) slate d
(11)rheostat resistan

This outfit sells f
$55.00 complete a
would soon pay for i
self in any garage.

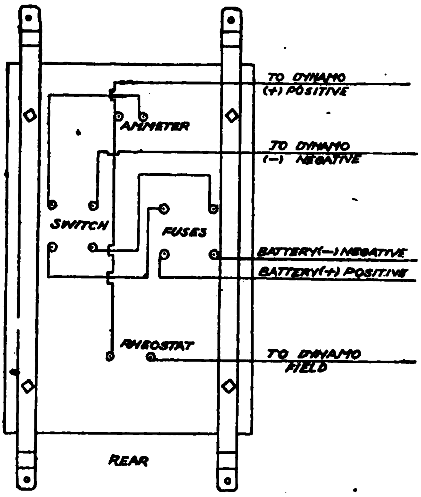


Fig. 3—Rear of switch-board showing connections. (Main.)

The G. E. Motor-Generator (fig.5 below).

Fig. 5. This battery-charging outfit is designed especially for the purpose of recharging automobile lighting and ignition batteries. The outfits are furnished in five sizes, suitable for the private garage to that required for the large public garage which has quite a number of batteries to recharge daily.

The outfits consist of a small motor-generator set (either alternating or direct current motor coupled to direct current generator) with switchboard panel mounted thereon.

The switchboard panel has a voltmeter for indicating the voltage, and an ammeter for indicating the amperes of the charging current delivered to the batteries being charged. There is also a generator field rheostat for controlling the charging voltage and current, and a snap switch arranged to open or close both charging and motor circuits at a single turn.

Ratings of Outfits: These outfits are furnished for service on either 110 or 220 volts, 60 cycles alternating current circuits, or for 110 or 220 volts direct current circuits, and as before stated, are furnished in five sizes, 175, 250, 375, 500 and 750 watts output. The 175- and 250-watt outfits, can be furnished for generator voltages of 12, 18 or 24 volts as desired. The 375-watt outfit is furnished for 36 volts, the 500-watt outfit for 48 volts, and the 750-watt outfit for 72 volts.

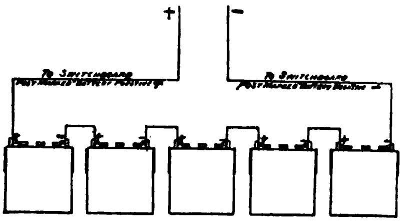


Fig. 4—Method of connecting batteries to be charged, (in series).

Any combination of voltages can be had up to 30 volts.

For instance 5, 6 volt batteries could be connected in series, or one 18 volt and one 12 volt battery—or two 12 volt and one 6 volt, etc.

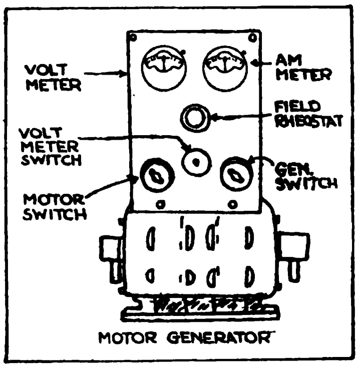


Fig. 5. General Electric Motor-Generator Set.

The rheostat mounted on the switchboards have in all cases sufficient capacity to reduce the voltage generated to one-quarter of that for which the outfit is rated.

By reducing the voltage generated by means of the rheostat, the 24-volt outfits can therefore be used for charging batteries as follows:

One 6-volt battery.
One 12-volt battery.
Two 6-volt batteries.
Two 12-volt batteries.
Three 6-volt batteries.
One 18-volt battery
Four 6-volt batteries.
One 24-volt battery.
One 6 and 1-12v. bat.
One 6 and 1-18v. bat.
Two 6 and 1-12v. bat.

ART NO. 205-A—Battery Charging Outfits; the Main Belt Driven Generator. The G. E. Motor-Generator. Information as to where to obtain motor-generator sets, charging plants etc., will be supplied by yke. Pub., St. Louis, Mo. The St. Louis E. W. Motor-Generator sets are giving excellent sa

witches permit current to pass through **wo, four, six** and eight and so on up to all **hirty lamps** and then through the batteries **n series with them.**

‡Resistance unit: Instead of lamps, resistance units (fig. 11, chart 205-AA) of approximately 35 ohms *resistance and 3.3. amperes capacity each may be used. This equipment will occupy less space than the **lamps and** serve the same purpose.

††Rheostat:—Instead of either a lamp resistance or unit resistance panel, a rheostat can be used, see fig. 25, page 460.

Number of Batteries to Charge (each having 3-cells)	To Charge Batteries at 3 Amps.		To Charge Batteries at 5 Amps.	
	Ohms of Resistance Necessary	Tap To Which To Connect Battery	Ohms of Resistance Necessary	Tap To Which Connect Battery
1	34.6	A	20.7	F
2	32.5	B	19.5	G
3	30.3	C	18.2	H
4	28.3	D	16.9	I
5	26.3	E	15.7	J

Fig. 18. Table showing ohms resistance required for battery charging—referred to in chart 205-AA.

Rectifiers.

Alternating current flows alternately in opposite directions and is used to a great extent for house lighting. Only **direct current** which is constant or a continuous current, is suitable for charging storage batteries.

Alternating current can be rectified so it will flow in one and the same direction. It can then be used for charging storage batteries and such a device is called a **rectifier.**

There are several types of rectifiers as follows:

1—Chemical rectifier, page 466.
2—Mercury arc rectifier, page 465.
3—Motor-generator set, page 462.
4—Synchronous commutator type.
5—Tungar rectifier, page 465.
6—Vibrator type, pages 465, 466.

The synchronous commutator type rectifier is merely an alternating current motor with which a commutator is used to change the alternating current to direct current.

The vibrator type rectifier is divided into two classes; one whereby the storage battery being charged, determines the polarity of the charge and the other whereby a permanent-magnet determines the polarity of the charge, per page 465, fig. 62.

With this, and previous mentioned rectifiers it is important that positive and negative poles of battery be connected to the positive and negative of the rectifier.

On one other type of vibrator rectifier, which is similar to fig. 62, page 465, but minus the permanent-magnet, there is another winding on the electro-magnet, which is "shunted" across the battery terminals and which takes the place of the permanent magnet.

****With this type it does not matter which of the terminals connects with the battery,** as the voltage from the battery will set up its polarity in the electro-magnet. The disadvantage, however, is that if battery is almost totally discharged there will not be sufficient voltage to excite the electro-magnet which should determine the polarity of the charge.

Water Rheostat and Chemical Rectifier.

More or less confusion exists, relative to the difference between a Rectifier and a Water Rheostat, due to their similarity of construction.

They are however, vastly different both as to action and principle.

One of the most undesirable features of Rectifiers similar to that shown in fig. 22, chart 205-C, is its internal resistance, whilst in a water rheostat, the resistance is its main feature.

Where current is rectified from alternating to direct by chemical action, the current flows in one direction, **and deposits** a coating of aluminum hydroxide, which insulates the aluminum electrode, **from the liquid. This must be scraped off from time to time, to keep down as much resistance as possible.**

The construction and action of a water rheostat is as follows: Say current is to be taken from 500 volt direct current—to pass 8 to 9 amperes; use a 5 gallon stone jar and mix 1 part sulphuric acid to 3 gallons water. Use 2 lead plates or soft metal as electrodes; the main requisite being that they have sufficient area to keep the heating effect down as low as possible. Current applied at one terminal leaves the plate and passes through **the water to the other plate. One of these is made stationary and the other movable and the resistance is regulated by changing their relative distance apart. The farther they are apart the greater the resistance. During the action of the rheostat, the water is decomposed into its natural elements,—oxygen and hydrogen,—and the loss must be made up occasionally by the addition of more water.**

The prime object of a rheostat (see page 474) is to cut down the voltage; of a rectifier, to change alternating current into direct current.

***Storage Battery Repairing.

To properly repair storage batteries the tools and supplies as well as a lead burning outfit is required, as per chart 205-F.

†The usual battery troubles are sulphating and buckling of plates, broken down separators and sediment accumulation in the bottom of the jar.

To repair a battery it must first be disassembled.. Before disassembling the defective cell should be located by testing, and inasmuch as other cells may be on the verge of a break-down it is advisable to disassemble all cells. If other cells are not defective, they should be washed and new separators added.

Disassembling.

To disassemble: The first step is to remove the filling plugs, to give more room to work upon the battery terminals. Then disconnect the terminals and intercell connectors, the sealing compound which covers the jar is removed first by using a hot putty knife. Steam or a flame is also used to first soften the compound.

Next: Remove connectors (fig. 23, chart 205-E) as follows: take a brace with a 5/8 inch wood bit and bore lead connector centrally over each post. (Fig. 24.) Then work off with a pair of pliers—another method; is to play a burning flame on the joint, at the same time pulling connector with a pair of pliers.

Be careful gas is not coming out of cell when handling a flame about it.

—continued on page 469.

---

*See page 207 "ohms" and 209 "resistance."

****When charging with the rectifier, the matter of connecting the positive of the charging source to positive of the battery** is important on all rectifiers except this one. ‡Can be obtained of Domestic Engineering Co., Dayton, Ohio.

*****These directions do not apply to any particular make of battery. We have used the "Exide" in many instances, to show** relation of one part to **another.**

†When to tear down a battery; when one or all of the cells do not take a charge after being on charge for 24 hours—then make a "cadmium test"—see index. ††See page 474.

Parts necessary to construct this 5 battery, charging outfit:

1—Double pole single throw switch.
2—10 amp. plug cut outs (fuses).
1—Ammeter, reading 0 to 30 amperes.
•40 ft. of No. 16 rubber covered flexible wire.
1—Resistance unit with two taps.
1—Resistance unit with nine taps.

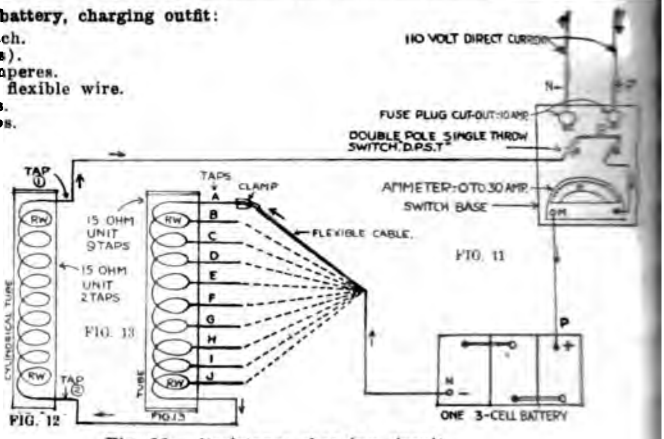


Fig. 11.—Resistance charging circuit.

Construction — The resistance units can be had of the General Electric Co. of Schenectady, N. Y. They are merely coils of wire (spiral resistance wire) wound on cylindrical tubes over asbestos and baked on the cylinder. The tubes are encased in porcelain and measure 22 inches long and 2 inches di.

Taps—There are two taps from each single resistance unit (fig. 12). Fig. 13 has 11 taps or connections. Each resistance unit in this example has 15 ohms capacity and is known as the 15E form P.

These resistance units are inexpensive, costing in the neighborhood of one dollar each.

Charging—Batteries are referred to generally—as 3-cell, 6-volt batteries. If a battery has 6 cells it is treated the same as two, 3-cell batteries; if it has 9 cells, it is treated the same as three, 3-cell batteries, etc. To figure the amount of resistance necessary to charge 1 o 5 batteries, that is; 3-cell batteries, on a 110 volt direct current line, note the following:

Resistance is always referred to as so many "ohms"—if one 3-cell battery is to be charged at a 3 amperage rate, figure resistance necessary to put in series with the battery as follows: N × SV = TV. In which N stands for number of cells, SV, stands for single voltage, or the voltage of one cell, and TV stands for total voltage. Submitting the letters for figures we have—3 cells (N) × 2.1 volts (SV) = 6.3 volts (TV). The total voltage of a 3-cell, 6-volt battery at beginning of charge.

$$\frac{110V - 6.3V}{3 \text{ amp.}} = 34.6 \text{ ohms} = \text{resistance required.}$$

Arrived at as follows; 110 — 6.3 = 103.7 ÷ 3 = 34.6.

If two, 3-cell batteries are to be charged at 3 ampere charge; multiply the 6.3V in above example by two—for instance:

$$\frac{110V - 12.6V}{3 \text{ amp.}} = 32.5 \text{ ohms} = \text{resistance required.}$$

If three, 3-cell batteries are to be charged at 3 ampere charge; multiply the 6.3V in the first example by 3; if four 3-cell batteries are to be charged multiply by 4; etc.

If the batteries are to be charged at 5 amperes, divide by 5, instead of 3 in the above examples, for instance:

$$\frac{110V - 6.3V}{5 \text{ amp.}} = 20.7 \text{ ohms} = \text{resistance required.}$$

To charge two 3-cell batteries at 5 amperes:

$$\frac{110V - 12.6V}{5 \text{ amp.}} = 19.5 \text{ ohms resistance required etc.}$$

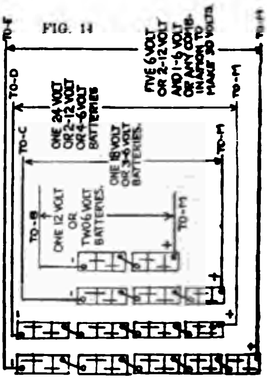


FIG. 14
TO-F
TO-D
TO-C
TO-B
TO-M
TO-M
TO-M
TO-M
FIVE 6 VOLT OR 2-12 VOLT AND 1-6 VOLT OR ANY COMBINATION TO MAKE 30 VOLTS
ONE 24 VOLT OR 2-12 VOLT OR 4-6 VOLT BATTERIES
ONE 18 VOLT OR 3-6 VOLT BATTERIES.
ONE 12 VOLT OR TWO 6 VOLT BATTERIES.
+
−

Fig. 14.—Method of connecting more than one battery to charge. Note batteries are connected in series—the positive pole of one battery, to negative pole of another, etc.

To increase the amperage of charge, say to 10 amperes per hour; divide by 10 instead of 3 or 5 amperes and cut out enough units, to give the required resistance necessary.

To operate on a higher voltage than 110 volts, as explained in the example above; say 220 or 500 volts—to find resistance necessary, use 220 or 500 instead of 110 volts.

How to charge—the two resistance units (figs. 12 and 13) in diagram, give 15 ohms each, or a total of 35 ohms (actual addition shows 30 ohms, but will give 35). One of the units (fig. 13), has 11 taps, so that the entire 11 resistance coils (RW) can be thrown into the circuit or only part of them as shown in diagram. The resistance unit (fig. 12) is connected at all times, which is 15 ohms. The other 15 ohms in fig. 13, can be subdivided as follows:

By merely connecting the wire from battery (— negative) to A—all resistance (30 ohms—will give 35) is in the circuit. When connected with (J) only the resistance in unit (fig. 12) is in circuit. Table fig. 18, page 463 will explain how and why the resistance units are added or cut out.

By following the arrow points, on diagram, from + P wire, over switch from the main wire, the circuit can easily be traced. The dotted lines represent the connections at different taps on the fig. 13 unit.

When connection is at A, this gives the least current, as the entire 30 ohms is in circuit. When at F, 22½ ohms resistance is in the circuit. The ampere current flowing may be read on the ammeter. The actual current will depend upon the number of batteries in series, as per diagram fig. 14. If the current obtained at A, is not sufficient, then cutting out resistance by connecting with B, or C and so on, each giving a greater current than the one preceding; the maximum being given at J.

As the batteries become charged the rate will become less, but may be increased again to 5 amperes, by proceeding with the next operation of cutting-out resistance. Charge until the specific gravity has reached a maximum (see page 461), and remained there for five hours. This is the standard, indicating completion of charge. The cells should gas at the same time. If they do not the maximum gravity has not been reached. The important point to watch in charging is not to let the temperature of the cell get above 110°. If it does the charge must be temporarily stopped, until the cell cools down, and then continued at a lower rate. But be sure to charge until the specific gravity has remained at a maximum for 5 hours. In case one battery becomes charged first it should be taken out of circuit and the remaining batteries charged at 5 or 6 amps. until the charge is completed.

CHART NO. 205AA—Charging Batteries with Resistance Units. A Practical Home-Made Charging Outfit—from Direct Current Source only. See page 463 for Table Showing the Ohms Resistance Required. See also 474 for explanation of resistance. A charging plant suits towns where there are no electric plants and for garages is shown on page 824.

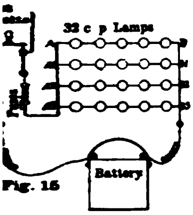


Fig. 15

Charging From 500 Volt Circuit.

Fig. 15—To charge a battery from a 500 volt direct current circuit: We will use 32 c. p. 100 volt lamps. In order to not burn out the lamps, place five in series, as A to B.

The five lamps however. owing to the **series** connections will not allow but one ampere to pass. In order to pass **two amperes**, another bank of five are placed in a parallel or multiple connection as at A1 to B1. For **three amperes**, another row from A2 to B2. For **four amperes**, another row A3 to B3. Therefore, four amperes of current would pass to **battery**. **If five amperes** were desired use **five more lamps** connected as above.

Charging From a 220 Volt Circuit.

As the voltage increases the amperage decreases. Therefore a 32 c. p. 220 volt lamp takes but ½ ampere. The same method as fig. 1 and fig. 37 page 460, can be used, but use 220 volt lamps. If 10—220 volt lamps are used, arranged as shown in fig. 1 and on a 220 volt circuit, only 5 amperes would be obtained. Therefore 20, 220 volt 32 c. p. lamps would be required for 10 amperes, or 60 for 30 amperes.

Another plan would be to use 2—16 c. p. 110 volt lamps in "series," but "parallel" to the circuit per fig. 30 below. This would give 1 ampere for each pair of lamps. Therefore 8, 110 volt, 32 c. p. lamps connected per fig. 30 would give 4 amperes.

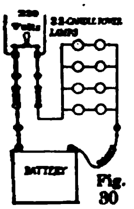


Fig. 30

Lighting Garage With The Charging Current.

A current economy in charging storage batteries can be effected by utilizing the current that is ordinarily consumed by the resistance shown in fig. 15, and on page 460, in lighting the garage at the same time. The banks of lamps can be placed separate from where the charging is being done if correct size wire is used.

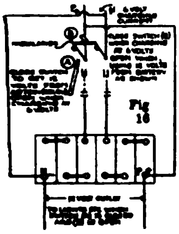


Fig. 16

Charging 12 Volt Battery on 6 Volt Circuit.

Fig. 16—A simplified illustration showing how to charge a 12-volt battery from a 6-volt direct current circuit is shown in illustration. The 3rd and 4th cells are not connected, but wires connect with a single pole switch, which is closed when battery is being used for 12-volts. When being charged at 6 volts, the single pole switch (A) is opened and switch (B) places the two sets of 3 cells in parallel.

Rectifiers—see also page 463.

Fig. 5—The mercury arc rectifier is used considerably for charging electric vehicle batteries. A maximum of 30 amperes is the average. A large glass tube contains mercury in its base. Graphite terminals 1 and 2, are the "anodes." Terminal 3, is the "cathode" for negative wire, there being only one. G, is the transformer. A small electrode 4, connected to one side of the alternating current, is used for starting the arc across the mercury. Tilting the tube, causes a mercury bridge between the terminals and produces an arc when tube is turned in a vertical position. When the current alternates, first one, and then the other "anode" (1 and 2), becomes positive, and a continuous flow is towards the mercury "cathode" (3), thence to battery, back to opposite side of supply.

Figs. 59, 60—The Tungar rectifier consists of a hot argon low pressure gas filled bulb B, fig. 60 and fig. 59, with a "cathode" F, (Tungsten filament) and an "anode" A, transformer T, for exciting the filament, rheostat R, and the load which is shown as a storage battery. The connections in fig. 60 show the half wave rectifier in its simplest form.

Principle: Assuming an instant when the side C of the alternating-current supply is positive, the current follows the direction of the arrows through the load, rheostat, bulb. and back to the opposite side of the alternating-current line. A certain amount of the alternating current of course, goes hrough the transformer T to excite the filament, the amount depending on the capacity of the bulb.

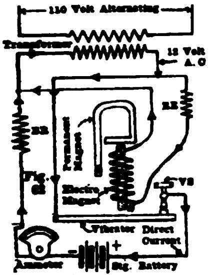


Fig. 62.

When the alternating-current supply reverses and the side D becomes positive, the current is prevented from flowing. In other words, the current is permitted to flow from the "anode" (A) to the "cathode" (F), or against the flow of emitted electrons from the cathode, but it cannot flow from the cathode to the anode with the flow of electrons.

Fig. 62—The vibrator type rectifier is divided into two classes; one with a transformer which transforms the alternating current from 110 volts to 10 or 12 volts. The current then passes through an "electro-magnet," the amount of current to operate the vibrator being regulated by resistance RE, fig. 62, page 465.

The purpose of the electro-magnet, vibrator and permanent-magnet is as follows: If the alternating current flowing through the electro-magnet is 120 cycle waves per second, the core (N) of electro-magnet would change its polarity each cycle wave.

If, however, some means were employed to **cut out 60 of the cycle waves,** and utilize only **one-half of the waves,** or only every other cycle wave which **flows in one direction** and which would be a direct flow of current, then the vibrator would close the circuit to battery at VS, and charge battery.

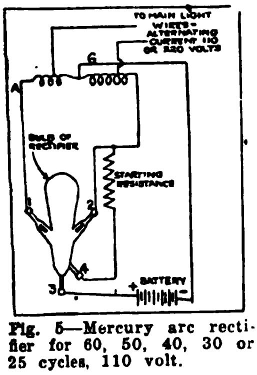


Fig. 5—Mercury arc rectifier for 60, 50, 40, 30 or 25 cycles, 110 volt.

This is **possible,** by placing a "permanent magnet" at the end of the electro-magnet, as shown in fig. 62, which keeps the electro-magnet core definitely N. & S. During the time the 60 cycle waves per second are flowing one way or in harmony with the permanent magnet polarity, the vibrator "cuts in" the battery, and during the time the 60 cycle waves flow in the other direction. the vibrator is not attracted by the core (N), because current is flowing in an opposite direction to that of the polarized magnet core and magnetism is not set up.

A spring, not shown, is attached to the vibrator which is **adjusted** to hold vibrator away from the core (N) until current flowing in harmony with the permanent magnet polarity, both combined, draws the vibrator to core. The **resistance** (BR) fig. 62, is used to limit the amount of charging current to battery, say 6 amperes.

Positive and negative wires must be connected correctly, but on **another type of vibrator rectifier,** as explained on page 463, this is not necessary.

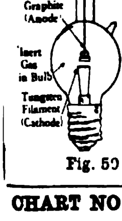


Fig. 59

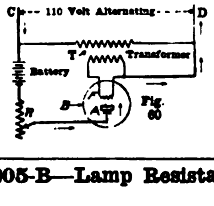
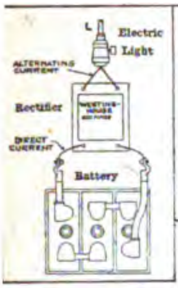


Fig. 60

CHART NO. 205-B—Lamp Resistance—Continued from page 460. **Rectifiers.**



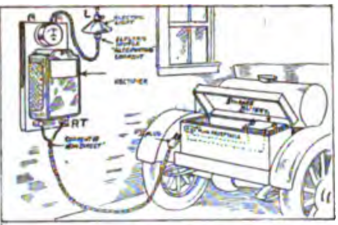


Fig. 20. A Westinghouse alternating current rectifier. Suitable for charging a storage battery.

Fig. 21—Another make of rectifier of a similar principle, is explained on page 463, 465. The current starts in one end alternating and passes out of rectifier into battery as direct current. The two above rectifiers will charge a single 3 cell battery at 5 amperes—from 110 volt circuit.

***When charging with this rectifier, the matter of connecting the positive of the charging source to the positive of the battery is not so important** as it is when charging from 110 volt direct current through lamp bulb resistance, as the rectifier as soon as connected, establishes its own polarity or proper direction of current if of the "electro-magnet-vibrator type" explained on page 463.

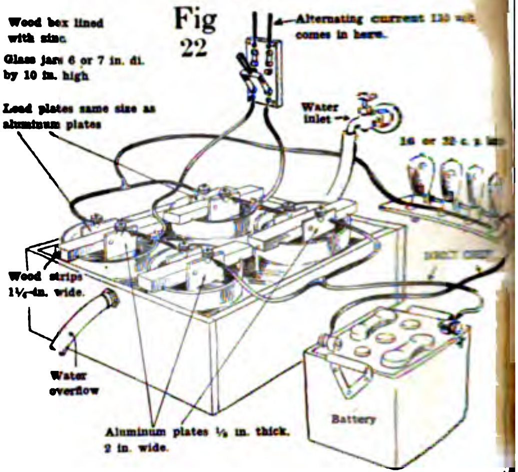
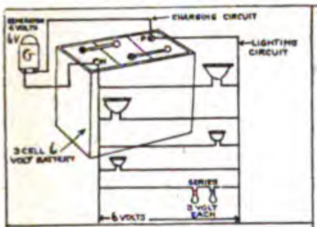
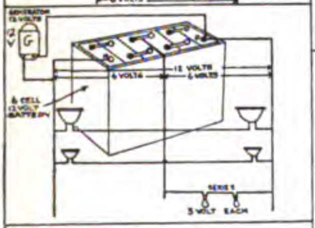


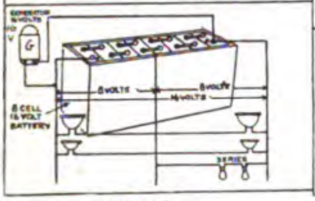
Fig
22
Wood box lined with zinc
Glass jars 6 or 7 in. di. by 10 in. high
Lead plates same size as aluminum plates
Alternating current 110 volt comes in here.
Water inlet
16 or 32 c. p. lamps
Wood strips 1½-in. wide.
Water overflow
Aluminum plates ⅛ in. thick. 2 in. wide.
Battery

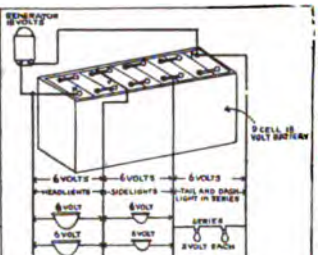
****Fig. 22—A chemical rectifier—not very efficient, but can be utilized if a better system is not suitable.** There is a tendency for liquid in jars to get hot and boil if too high a current is passed through it, otherwise water not necessary.

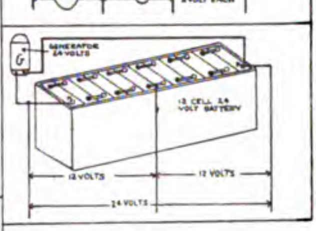
Amount of charging current is regulated by using 16 or 32 c. p. lamps, ½ ampere will pass through a 16 c. p. lamp and 1 amp. through a 32 c. p., therefore more lamps, more amperes flowing. About amperes or 4—16 c. p. lamps is best with this outfit, which of course would require a long time to charge 100 ampere hour battery if entirely exhausted. (Motor Age.)











Battery Connections.

The explanation of lamp connection diagrams here shown starts with the upper left hand illustration.

(1st) A 6-volt 3-cell battery from which the head lights are 6 volts. 3 volt tail and dash light are connected in series.

(2nd) (Just below) a 12-volt, 6-cell battery from which we have connected 6-volt lamps, using a "neutral" or third wire connection as shown in illustration. The battery is charged from a 12-volt generator.

(3rd) This 16-volt 8-cell **battery is connected in the same manner** using 8-volt lamps between **the third wire.**

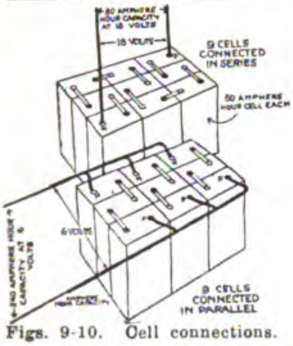
(4th) (Upper right) **From the 18-volt, 9-cell battery we have** made three separate circuits **of 6 volt each. This system must necessarily** have to be "balanced," **that is, equalise the current taken from** each group of three cells **each, else the charging would not be** uniform. This could be **balanced better than shown in the illustration.** Note the load is not equalized.

(5th) 24-volt, 12-cell **battery divided, two circuits 12-v. each.**

Fig. 9. Note we have 9 **cells connected in series, (upper illustration),** each cell gives 2 volts, in fact **all cells give 2 volts, but the amperage or** output varies according to **the size and number of plates to each cell.** Suppose in this instance, **each cell is an 80 ampere hour capacity cell.** In the series connection we **would have 18 volts and 80 ampere hour** output.

Fig. 10. If cells were **connected is series parallel, with 3 cells in** series and **then parallel or multiple connection as shown, we would have** at the terminals, the voltage **of 3 cells, or 6 volts and the amperage of 3** cells, or 240 ampere-hour **capacity.**

Note 18-volts x 80-amp.=**1,440 watt hours, and 6-volts x 240-amp.=** 1,440 watt hours. Showing **that the total out-put is the same, the** only difference being the **rate of out-put.**


80 AMPERE HOUR CAPACITY AT 18 VOLTS
18 VOLTS
9 CELLS CONNECTED IN SERIES
80 AMPERE HOUR CELL EACH
240 AMPERE HOUR CAPACITY AT 6 VOLTS
6 VOLTS
9 CELLS CONNECTED IN PARALLEL

Figs. 9-10. Cell connections.

CHART NO. 205-C—Rectifiers for Charging Single Batteries. Explaining How Storage Battery Cells can be Arranged to give Various Voltages.

**The solution consists of a concentrated solution of common baking soda in pure water.

*See foot note, page 463.

U-S-L 6-VOLT IGNITION BATTERIES

atalog umbers	"L" in Inches	"W" in Inches	"H" in Inches	Wts. Lbs.	Number Hours Continuous Sparking	CHARGING RATES IN AMPERES Starting Rate	Finishing Rate	24-Ho Rate
-307	6¼	7⅜	8⅞	30	70 Hrs	6	1½	2¼
-309	8 1/16	7⅜	8⅞	36	90 "	8	2	3
303	5 3/32	6⅜	8⅞	17¼	30 "	2	1	1½
305	7 1/16*	6⅛	8⅞	28¼	60 "	4	2	3

U-S-L 6-VOLT LIGHTING BATTERIES

Lighting Batteries Cannot be Used for Starting.

					LIGHTING CAPACITIES			CHARGING RATES IN AMPERES		
atalogue umbers	"L" in Inches	"W" in Inches	"H" in Inches	Wts. Lbs.	Number of Hours Batteries will Sustain Ampere discharges of 1 Ampere	5 Amperes	7½ Amperes	Starting Rate	Finishing Rate	24-Hou Rate
L-307	6¼	7⅜	8⅞	30	50 Hrs	7 Hrs	4 Hrs	6	1½	2¼
L-309	8 1/16	7⅜	8⅞	36	70 "	10.5 "	6 "	8	2	3
L-311	9⅛	7⅜	8⅞	43	90 "	14 "	8 "	10	2½	3¾
L-313	10 11/16	7⅝	8⅞	49	110 "	18 "	10.5 "	12	3	4½
L-315	12	7⅜	8⅞	56	130 "	21.2 "	13 "	14	3½	5¼
L-319	14⅝	7⅜	8⅞	69	170 "	28.8 "	18 "	18	4½	6¾
L-307	6¼	7⅜	9⅛	31	60 "	8.5 "	4.8 "	7	1¾	2⅝
L-309	8 1/16	7⅜	9⅛	39	85 "	12.6 "	7.2 "	9	2¼	3⅜
L-311	9⅛	7⅜	9⅛	47	105 "	16.8 "	9.9 "	11	3	4¼
L-313	10 11/16	7⅝	9⅛	55	130 "	21.2 "	12.6 "	14	3½	5
L 315	12	7⅜	9⅛	63	150 "	25.2 "	15.5 "	16	4	6
L-307	6¼	5⅜	10⅛	30	50 "	7 "	4 "	6	1½	2¼
L-309	8 1/16	5⅞	10⅜	36	70 "	10.5 "	6 "	8	2	3
L-311	9⅛	5⅜	10⅜	43	90 "	14 "	8 "	10	2½	3¾
FL 313	10 11/16	5⅜	10⅛	49	110 "	18 "	10.5 "	12	3	4½
FL 315	12	5⅜	10⅛	56	130 "	21.2 "	13 "	14	3½	5¼
FL-319	14⅝	5⅞	10⅜	69	170 "	28.8 "	18 "	18	4½	6¾
K-307	9 1/32	6⅜	8⅞	35¼	70 "	10.2 "	6 2 "	6	3	4½
K-309	11⅛	6⅜	8⅞	46¼	92 "	15.5 "	9 "	8	4	6
K-311	13 11 32	6⅛	8⅞	55¼	120 "	20 "	12 "	10	5	7½

U-S-L STARTING AND LIGHTING BATTERIES - 6 Volt.

					LIGHTING CAPACITIES			STARTING CAPACITY	CHARGING RATES IN AMPERES		
Catalogue Numbers	"L" in Inches	"W in Inches	"H" in Inches	Wts. Lbs.	No. Hours batteries will Sustain ampere discharges of 1 Ampere	5-Amperes	7½ Amperes	Minutes Batteries will sustain ampere discharge of 120 amperes	Starting Rate	Finishing Rate	24-Hour Rate
A-311-B	9⅛	7⅜	8⅞	43	90 Hrs	14 Hrs	8 Hrs	11 5 Min.	10	2½	3¾
A-313-B	10 11/16	7⅜	8⅞	49	110 "	18 "	10.5 "	15 "	12	3	4½
A 315 B	12	7⅜	8⅞	56	130 "	21.2 "	13 "	18.8 "	14	3½	5¼
A-319 B	14⅝	7⅜	8⅞	69	170 "	28.8 "	18 "	27.2 "	18	4½	6¾
C-311-B	9⅛	7⅜	9⅛	47	105 "	16.8 "	9.9 "	14.2 "	11	3	4¼
C-313-B	10 11 16	7⅜	9⅛	55	130 "	21.2 "	12.6 "	18.7 "	14	3½	5
C-315 B	12	7⅜	9⅛	63	150 "	25.2 "	15 5 "	23.5 "	16	4	6
C-317-B	13 5/16	7⅜	9⅛	71	175 "	29.5 "	18.1 "	28.5 "	18	4½	6¾
G-311-B	9⅛	7⅜	11⅛	62	130 "	22 "	13.5 "	20.5 "	14⅛	3⅝	5⅜
G-315-B	12	7⅜	11⅛	80	185 "	33.2 "	20.5 "	33.5 "	20⅛	5	7⅝
F-311-B	9⅛	5⅞	10⅜	43	90 "	14 "	8 "	11.5 "	10	2½	3¾
F-313-B	10 11/.6	5⅞	10⅛	49	110 "	18 "	10 5 "	15 "	12	3	4½
F-315-B	12	5⅜	10⅛	56	130 "	21.2 "	13 "	18 8 "	14	3½	5¼
F-319-B	14⅝	5⅜	10⅛	69	170 "	28.8 "	18 "	27.2 "	18	4½	6¾
12 Volt Batteries											
A-607-B	12⅛	7⅜	8⅞	57	50 Hrs	7 Hrs	4 Hrs	5.1 Min.	6	1½	2¼
A-609-B	15	7⅜	8⅞	70	70 "	10.5 "	6 "	8.4 "	8	2	3
A 611 B	17⅝	7⅜	8⅞	84	90 "	14 "	8 "	11.5 "	10	2½	3¾
A 613 B	20¼	7⅜	8⅞	97	110 "	18 "	10.5 "	15 "	12	3	4½
C 607-B	12⅛	7⅜	9⅛	63	60 "	8.5 "	4.8 "	6.5 "	7	1¾	2⅝
C-609 B	15	7⅝	9⅛	79	85 "	12.6 "	7 2 "	10.1 "	9	2¼	3⅜
C 611-B	17⅝	7⅜	9⅛	95	105 "	16 8 "	9 9 "	14.2 "	11	3	4¼
C-613-B	20¼	7⅝	9⅛	111	130 "	21.2 "	12.6 "	18.7 "	14	3½	5
G-607-B	12⅛	7⅝	11⅛	86	80 "	11.8 "	6 7 "	9.3 "	8¾	2¼	3¼
G-609-B	15	7⅝	11⅛	104	105 "	17 "	10 "	14.2 "	11⅝	3	4⅜
F-607-B	12⅛	5⅞	10⅛	57	50 "	7 "	4 "	5.1 "	6	1½	2¼
F-609-B	15	5⅜	10⅛	70	70 "	10.5 "	6 "	8.4 "	8	2	3
F 611-B	17⅝	5⅞	10⅛	84	90 "	14 "	8 "	11.5 "	10	2½	3¾
F 613-B	20¼	5⅜	10⅜	97	110 "	18 "	10.5 "	15 "	12	3	4½
F-615-B	23	6	10⅛	110	130 "	21.2 "	13 "	18.8 "	14	3½	5¼
EL-607-D	10 5/16	7⅛	9	54	45 "	5.8 "	3.1 "	4 "	5	1¼	2
EL-613-B	21 13/16	5 13/16	10 7/16	89	100 "	14.8 "	8.7 "	12 "	10	2½	3¾
LA-613	21¼	7 9/16	9⅛	97	110 "	18 "	10.5 "	15 "	12	3	4½
18 Volt Batteries											
A-909-B	22 3/16	7⅛	9	103	70 Hrs	10.5 Hrs	6 Hrs	8.4 Min.	8	2	3
F-907-A	15 11/16	6¼	9	84	50 "	7 "	4 "	5.1 "	6	1½	2¼
F-909-A	15 13/16	8 1/16	10⅛	103	70 "	10.5 "	6 "	8.4 "	8	2	3
F-911-A	15 13/16	9⅝	10⅛	122	90 "	14 "	8 "	11.5 "	10	2½	3¾
F-907-B	18¼	5⅞	10⅝	84	50 "	7 "	4 "	5.1 "	6	1½	2¼
EDC-909	15	8⅛	12⅛	105	70 "	10.5 "	6 "	8.4 "	8	2	3
24 Volt Batteries											
A-1207-A	12⅛	14	9	112	50 Hrs	7 Hrs	4 Hrs	5.1 Min.	6	1⅛	2¼
A-1207-B	23⅜	7⅛	9	112	50 "	7 "	4 "	5.1 "	6	1⅛	2¼
F-1207-A	12⅛	11	10⅛	112	50 "	7 "	4 "	5.1 "	6	1⅛	2¼
EL-1207	19¼	7⅛	10 7/16	105	45 "	5 8 "	3.1 "	4 "	5	1¼	2
EL-1209	19¾	8¾	10 7/16	127	60 "	8.7 "	4.7 "	6.6 "	6¼	1¼	2⅛

With Tungsten Lamps, one Ampere is equivalent to 6 Candle Power, or 2 side and 1 Tail light.
" " " five " " " " 30 " " " 2-12 C. P. Head, 2 side and 1 Tail light.
" " " 7½ " " " " 45 " " " 2-18 " " 2 side and 1 Tail light.
ONE AMPERE, with 6 Volt Tungsten lamps is equivalent to 6 Candle Power, or 2 side and 1 Tail light.
FIVE " " " " " " " " " 30 " " " 2-12 C. P. Head, 2 side and 1 Tail light.
SEVEN and ONE-HALF AMPERE with 6 Volt Tungsten lamps is equivalent to 45 C. P., or 2-18 C. P. Head, 2 side and 1 Tail.
*See text stating how the catalog numbers indicate the number of cells and plates.

COART NO. 205-D—Charging Rates. Ampere Hour Capacities. This Table is Applicable to Othe Batteries. *See page 448. See pages 432 and 433 for current consumption of

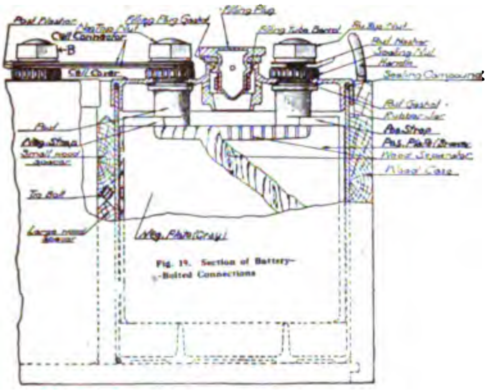


Fig. 19. Section of Battery—Bolted Connections

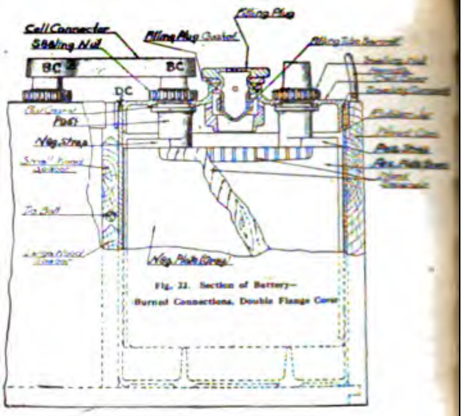


Fig. 22. Section of Battery—Burned Connections, Double Flange Cover

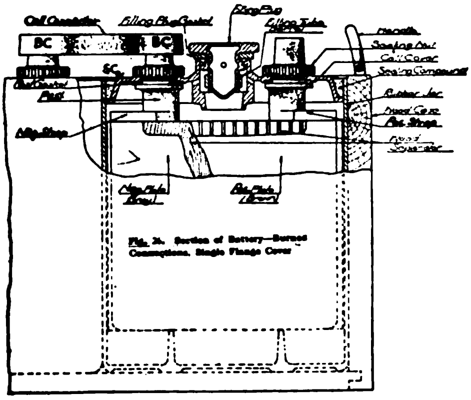


Fig. 26. Section of Battery—Burned Connections, Single Flange Cover

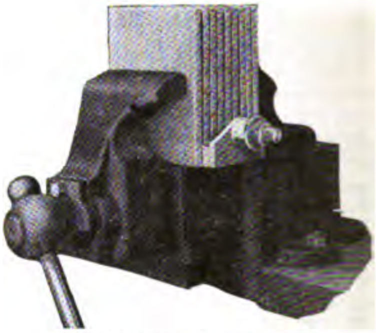


Fig. 30. Straightening plates.

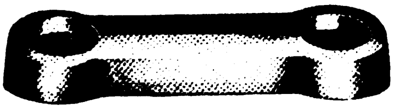


Fig. 23 A lead connector.

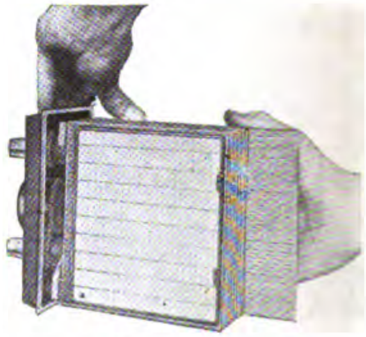


Fig. 31. Inserting separators.

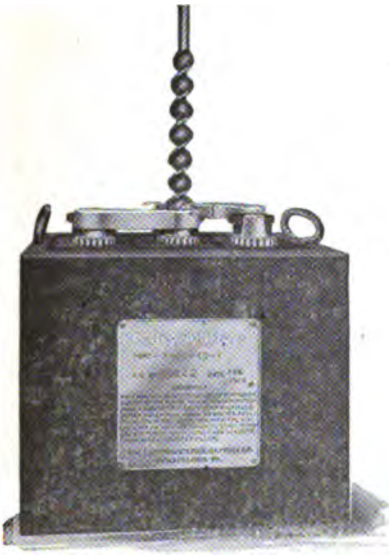


Fig. 24. Boring a lead connector.

The top construction shown in Fig. 1, chart 203-A is common to all modern types of "Exide" starting and lighting batteries.

There are three general types, differing in minor details which are clearly set forth in Figs. 19, 22 and 26.

Fig. 19 shows the bolted connection type, which always takes the double flange cover.

Fig. 22 shows the **burned connection type with the double** flange cover—(DC).

Fig. 26 shows the **burned conection type with the single flange** cover—(SC).

CHART NO. 205-E—Illustrations Explaining the Burned and Bolted Connectors. Single and Double Flange Tops of Battery Cells. Straightening Plates. Inserting Separators.

Exide illustrations are used as examples.

—continued from page 468.

After the connections are removed, unseal · **heating** a flat-bladed knife (a putty knife ill **answer**) in a flame, and run it through e **sealing** compound close to the jar wall l **the** way around. This will loosen the mpound, and the element with the cover it can be lifted out of the jar.

If elements are difficult to remove, don't ull too hard—if they do not come—fill cell ith boiling water, which will soften the hole cell, and plates will come out readily.

Taking element apart: After removing he cover, lay the element down with the lates on edge and slightly spreading the lates, withdraw the separators one at a ime. The positive and negative groups can hen be separated and the dismantling is omplete.

How To Examine Plates.

Remove the group and examine plates by holding up side down and look down them and note if plates are warped or bulged out and if they press against separator, or if active material has worked between, thereby short-circuiting. Also see if separators are good.

If positive plates are not warped and separators are in good condition, yet battery will not hold charge, then the fault must be with the negative plates.

Examine negative plates, and see if the filler is bulged out and very porous or spongy and if active material has fallen out. At first glance you would hardly notice this, but examine carefully. If in this condition there is no need of putting in new separators, but put in new negative plates and separators, providing positive plates are good.

A battery with negative plates in poor condition will take a charge all right, the gravity test will be o. k. as will a voltage test, and have all the indications of a healthy battery, **yet will not hold up to capacity.** See also page 416.

When putting in new plates, be sure both are fully charged or discharged, or in same condition.

If negative plates are to be used again don't let them dry, but place the group in electrolyte or water—this will save time in charging after reassembling.

*How to Remove a Bad Plate.

Suppose you find that one or several of the positive plates are buckled or worn out, the best thing to do is to cut out the plate at the place where it is lead burned to the strap and a new one should be "lead burned" in its place. You will very seldom have to replace a negative plate, for they generally outlast two positive plates.

If a post is loose or in bad condition, it is advisable to have an entire new group of plates, either positive or negative as the case may be.

The positive plates should be examined particularly for washing out of material and buckling (warping). If the material has washed out on the surface to a depth below the base of the horizontal ribs, a new group should be substituted. If the plates are only slightly buckled, they can be replaced as they are, since this generally does no harm. If they are badly buckled, a new group should be substituted.

A buckled positive plate can be used again by cutting off outside rib about an inch from bottom on either end. See page 457, fig. 4 and note curve of plate when buckled. This causes a separator to be cut and shorts the plates.

****The negative plates are nearly always in good condition mechanically,** as they are not affected by abuse as readily as the positives. If the positives are buckled, the negatives will be also; but if in a charged condition, can be readily straightened as follows:

Place boards of suitable thickness between the plates and outside of the group and slowly apply a gradual pressure. This is best done in a vise, leaving the pile in the vise for some minutes during the operation to give the plates a chance to straighten without undue strain (fig. 30, chart 205-E).

If the battery has been badly abused, "starved" or neglected, the negatives may have shed material; in this case it is best to use a new group. If the negative material is very hard and not spongy, it is "sulphated," and particular care should be used that the subsequent charge is carried to maximum gravity.

The wood separators should be examined as to their physical condition—if soft and mushy and worn thin at several places—by all means change them, in fact, unless a battery is comparatively new, it is advisable to install new separators, whenever a cell is dismantled for repairs, since it is of vital importance in a battery to have the separators in good condition.

They should be kept in stock wet, preferably in water acidulated with electrolyte and when fitted, should extend about ⅛ in. over plates.

Perforated rubber sheets, when used are nearly always in condition to put back unless broken in handling. It is advisable to carry a small stock of these for emergencies.

The sediment in the bottom of the jars will rarely be found to have reached the plates, but whenever a cell is taken apart for any purpose, it is advisable to wash sediment out.

Sometimes impurities get into the electrolyte through carelessness or ignorance, but their detection is not practicable except by an expert chemist. As a precautionary measure, the use of new electrolyte of known purity is recommended when repairing.

Take a hydrometer reading of the old electrolyte before discarding, as this determines the proper gravity of the new electrolyte to be used in case the old plates are put back.

When the positive plates are badly disintegrated, it is usually a sign of foreign matter in the electrolyte, and in such a case it is safer to discard the negatives and separators as well, since they may hold some of the impurity and be the means of ruining the new positives in a short time.

Battery case: Unless there have been broken jars or abuse of some sort, the battery case will usually be found to be in good condition. If the case has become acid soaked and rotted, a new one should be used. When the old case is to be used again, it should be soaked in a solution of baking soda and water. This will neutralize any acid and prolong the life of the wood. Rinse with water and allow to dry thoroughly. Repaint the case inside and out with **asphaltum** or other **acid proof paint.**

---

*These directions do not apply to any particular make of battery. We have used the "Exide" in many instances, to show relation of one part to another. **See foot note, page 446 and note how negative and positive plates are arranged. ‡See index for "**Cadmium Tests.**"

††Carrying gravity of acid too high will also cause negative filler to bulge out.

Reassembling Battery.

After the necessary repairs have been made, the battery should be reassembled as follows:

Wipe the posts with a piece of waste moistened with ammonia, rinse with water and dry thoroughly with clean waste.

Assembling elements: Slip the positive and negative groups together without the separators and place the cover in position, being sure not to omit the soft rubber washers under the cover.

Inserting separators: Place the groups on edge (fig. 31, chart 205-E) and insert the separators, **being sure that the flat side of the wood goes against the negative plate.** (Where rubber sheets are used (types PH and MH), place one against the grooved side of each wood separator before inserting.) When the separators are all in place count them to be sure none are missing, stand the element up again and tap the edges of the wood separators with a wood block until they project equally on each side of the plates.

***How to seal the battery:** You are now ready to seal up your battery. Heat the sealing compound—you dug out—in a small bucket and apply a little with a putty knife around the places where the cell cover touches the cell. Let this get hard, then put in a small amount at a time, but always wait until it has become hard before you add more. If you add the sealing compound too fast it would run down through the crack into the battery. When filled, throw the flame on the sealing compound and smooth out the rough places.

Connectors: First see that the posts and the eyes of the lead connectors are clean and bright. If the disconnecting has been carefully done, the posts and connectors will be in good condition and need only washing with ammonia, followed (when dry), by slight polishing with sand paper or scraping with a knife. Place the connectors over the posts, lightly tapping them to a firm seat, and burn the joint, using a burning outfit (chart 205-F), or, if nothing better is available, a soldering iron. Do not use any soldering acid or other flux.

Filling Cells with Electrolyte.

Fill the cells with new electrolyte until the level rises in the filling tubes, and be sure to replace and tighten the filling plugs before starting to charge.

The specific gravity of electrolyte to use will depend upon the condition of the plates.

If new elements are used, fill with 1.375 gravity for all types of exide batteries, except PH and MH, which take 1.330 gravity.

If old plates and new separators are used, fill with electrolyte 50 points (.050 sp. gr.) higher than the old electrolyte. When the old separators are put back, **use the same** gravity as the old electrolyte. The electrolyte must be of proper purity (**pages** 448-449).

If electrolyte of the desired gravity is not at hand, electrolyte of any higher gravity can be diluted with pure water. To mix electrolyte from strong sulphuric **acid,** see pages 448-449.

Putting Acid and Separators into a Repaired Battery.

If battery was repaired for a short circuit, put 1,250 acid into the cells that were repaired. The reason you put such a high acid in the cells is because the acid soaks into the new separators. It is hard to tell just what gravity of acid to put into the cell. The best is to put in 1.250 and start charging. The acid in a short time will drop to about 1.100 and then as the charge goes on, it will gradually rise until it becomes constant, that is, the acid reading will be, say 1.200 and at the end of another five hours charging it will still be 1.200. This shows that the cell is fully charged, but the acid gravity is not high enough. Add a stronger acid until the gravity shows 1.260.

If you only repair one cell of a 6-volt battery, the other two cells should be discharged with a lamp or two during the time you are repairing the cell. If you would not discharge these two cells, afterwards when you charge the whole battery, these two cells would get too much charge.

Why Gravity Sometimes Drops on Inserting New Separators.

When it is necessary to put in new separators, and a new solution, it will sometimes result that in charging this battery that the gravity of the solution will drop rather than rise. This is due to the following causes; the separators will consume a certain amount of the strength of the acid and as the charging process continues the separators will be absorbing the acid as fast as it is driven from the plates. If the battery was in a discharged state when new separators were put in, then the charging current would drive acid from the plates faster than could be absorbed by the separators and would raise the gravity of the solution instead of lowering it, but in most cases, you will find that the solution either drops or stays as it was. Charging does not have much effect in cases of this kind.

If the storage battery is in a charged state and a new solution be put into it, it will also be impossible to bring the specific gravity up by charging. It will stay as when put in or fall off slightly. This is because there is no lead sulphate on the plates for the electrical current to change back into an acid solution. In cases of this kind the original solution put in battery should show a gravity between 1.275 to 1.300.

Charging after Repairing.

Do not start the charge until at least 12 hours after filling with electrolyte. This is to give the cells a chance to cool, and in very hot weather a longer stand may be necessary.

Charge at about one-half the normal charge rate, until the specific gravity and voltage show no rise over a period of 5 hours and all the cells are gassing freely. This will require at least 50 hours in the case of new elements, while with old plates which are badly sulphated or have dried out, considerably more time may be necessary.

Take occasional temperature readings, and if the temperature reaches 110 degrees F. either lower the current rate or interrupt the charge.

---

*This does not apply to Exide only—in fact we have varied the directions, so as to apply in general, to different batteries as much as possible.

When the charge is complete, adjust the ctrolyte to the proper level, continuing e charge to allow the gassing to thorghly mix the solution. Take a hydrometer ading on each cell and adjust the specific avity to the proper point (1.270—1.300).

Adjusting gravity: If the adjustment cessary **is slight,** this may be accomplished y removing some of the solution and addg water or stronger electrolyte as required.

If the adjustment necessary is considerble, it will be found more convenient to mpty out the solution and refill with elecrolyte of specific gravity estimated to bring t right, allowing for the effect of the old olution held in the cells. A little experience will enable the operator to gauge this quite accurately.

After any adjustment, charge for some minutes to allow the gassing to thoroughly mix the solution before taking hydrometer readings.

If the temperature is far from normal, correct the hydrometer readings by adding one point (.001 sp. gr.) for each 3 degrees above and subtracting one point for each 3 degrees below 70 degrees F. (See fig. 12, chart 204).

Always wipe off the top and sides of battery with weak ammonia after adjusting electrolyte.

[*]Lead Burning.

In batteries having burned connections, the joints are made by melting the parts to be joined and forming a solid weld. The process is called "lead burning," and is carried out by means of illuminating gas (with special burner), hydrogen gas or an electric arc.

In absence of such an outfit a fairly good job can be done by using a very hot, well tinned soldering iron, with pure lead as a solder.

Cleaning surfaces: In all lead burning, absolutely clean surfaces are essential to good workmanship. Lead is soft and very readily cleaned with a scraper or file. In the case of a battery which has had electrolyte in it, the surface to be burned should first be wiped with ammonia to neutralize the acid and then allowed to dry before scraping.

[†]**Before starting to burn,** the connector or terminal should first be lightly tapped to a snug fit on the post. The top of the post should be $\frac{1}{8}$ inch below the top of the connector to allow space for burning. If the post is too long, remove the connector and trim off the post.

Method of burning: The top of the post should be melted first and then fused to the connector, after which lead from a piece of burning strip can be run in until the joint is flush.

[*]The Illuminating Gas Outfit.

The outfit consists of a special burning tip and mixing valve. Sufficient $\frac{3}{16}$ inch hose should be provided, and the hose wired to the apparatus in making connections. The comparatively high air pressure renders this precaution advisable.

A supply of compressed air is necessary, the proper pressure ranging from 5 to 10 pounds, depending upon the length of hose and the size of parts to be burned. When air from a compressor for pumping tires is used, a suitable reducing valve must be introduced.

This outfit is designed for use with the ordinary city gas supply; **natural gas cannot be used.** See chart 205-F.

The hydrogen gas outfit is illustrated in chart 205-F.

The Arc Burning Outfit.

The advantage of the so-called "arc" burning lies in the fact that a spare six volt battery can be used as the source of current for the operation, rendering unnecessary the use of further accessory apparatus, like the hydrogen generator.

Although called the "arc burning outfit," more satisfactory results can be obtained by using the carbon after it becomes heated like a soldering iron, without actually drawing an arc.

Parts: This oufit (fig. 36), as supplied by The Electric Storage Battery Co., consists of the following parts: Carbon holder with cable, clamp and $\frac{1}{4}$ inch carbon rods—see chart 205-F.

Miscellaneous Storage Battery Repair Information.

Corrosion of the terminals or other parts of the connectors, should be prevented by coating them with vaseline or petroleum jelly. Sometimes they get so badly corroded that is is almost impossible to unscrew the terminals, and greasing them in this way will prevent recurrences of such trouble.

When overhauling a battery, it is a good plan to put all the connectors, terminals and other removable pieces at the top in a strong solution of soda and hot water and let them stay in it for about an hour, so that the solution will have plenty of time thoroughly to clean them. Then put on the vaseline and no more corrosion should appear. In the first place, it is usually the result of overfilling the jars or spilling the solution, which in time acts upon the lead and brass terminals.

A Cracked Battery Jar.

Never attempt to repair a cracked or broken battery jar, as this is impossible. When the jars get in this condition they must be discarded as useless.

It is not very much trouble to remove any cell from a battery because the makers have seen to this point. To take apart the

---

[*] A lead burning outfit—using acetylene and oxygen, oxygen and hydrogen, hydrogen and compressed air or illuminating gas and oxygen—whichever is the most available and which will do light welding also—is Mf'g'd by Imperial Brass Co., Chicago. See Instruction 46-C.

[†] In order to avoid the possibility of an explosion of the gaseous mixture when using a flame near a battery—place filling plugs in battery and cover entire battery with a wet cloth, pressing it down over vents of cells, except that part on which the burning operation is to be performed.

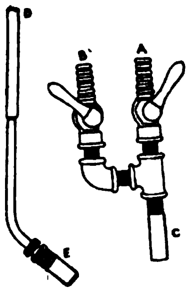


Fig. 34. Illuminating Gas Outfit.

Fig. 34.—How to use illuminating gas for burning. See p 471: Connect the air hose to cock A, the gas hose to cock B. T leader hose, which should not be more than 5 or 6 feet long, is connected to the pipe C and to the burning tip at D.

When the air pressure at the source is properly adjusted, close the air cock (A) and turn the gas cock (B) on full. Light the gas at the tip and then turn on the air. If the flame blows out, the air pressure is too high and must be reduced, preferably at the source.

With the gas turned on full, the flame will have a ragged appearance and show a waist about ½ inch from the end of the tip, the flame converging there and spreading out beyond. This flame is not suitable for burning.

Slowly turn off the gas until the outer portion at the waist breaks and spreads, with an inner tongue of flame issuing through the outer ring. The flame will now have a greenish color, and is properly adjusted for burning.

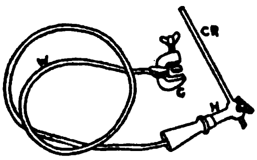


Fig. 86 An Electric Arc Burning Outfit.

If the gas is turned off further, or too much air is turned on, the flame assumes a blue color gradually becoming invisible, and is then deficient in heating power.

When properly adjusted, the hottest part of the flame is just past the end of the inner point. Do not hold the flame too close to the work when burning, as its heating effect is greatly reduced and the flame is spread so as to make control difficult.

The burning tip is provided with sleeve and lock nut (E). The sleeve is removable and can be taken off in case any of the holes in the tip become clogged. The position of this sleeve is adjustable, the best position varying with the pressure of the flame, etc. This position should be determined by experiment.

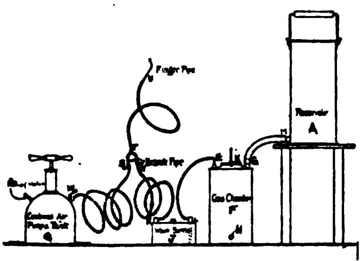


Fig. 85—Hydrogen Gas Outfit.

Fig. 86.—How to use the electric arc for burning: The method of using it for reburning connectors is as follows: One terminal of a spare six volt battery is connected by a piece of cable with the connector to be burned. The cable can be made fast to the latter by means of a clamp and care should be used that the surfaces are clean and a good contact secured. The cable attached to the carbon holder is then attached to the spare battery, either at the other terminal or on the connector of the cell adjoining, depending upon whether the battery is partially discharged or fully charged. In the latter case, three cells will give too much voltage and make the work difficult. The number of cells used should be sufficient to heat the carbon to at least a bright cherry red while it is in contact with the joint. The carbon should be sharpened to a long point like a lead pencil and should project not more than 3 inches from the holder. The latter should be cooled off occasionally by plunging it, carbon and all, into a pail of water. After being used for a short time, it will be found that the carbon will not heat properly, due to a film of scale formed on the surface. This should be cleaned off with a knife, or file, as occasion requires.

As in the case of flame burning, additional lead to make a flush joint should not be added until the metal of the pieces to be joined has melted. The carbon should be moved around to insure a solid joint at all points.

Fig. 85—The hydrogen gas—While more expensive and troublesome than illuminating gas, gives a hotter flame and therefore permits of more rapid work. Some garages doing a large amount of work may still prefer its use, although in most cases the use of illuminating gas offers more advantages.

The hydrogen outfit as illustrated in fig. 35, supplied by The Electric Storage Battery Company, Philadelphia.

CHART NO. 205-F—Battery Repairmen's Lead Burning Outfits.

See also pages 696 and 720 for gas torches.

nnectors on a Willard battery, for instance, e procedure is to drill a ¾-in. hole in the d of the connector, directly over the st. This hole should be drilled with any rm of drill and about two-thirds through e connector, when the latter will come f readily. The connectors have to be rned back on and more lead used to fill p the drilled out hole.

To remove a cell from an Exide battery, e top nuts and connections must first be aken off, the nuts unscrewing in the regu ar manner.

Celluloid jars can be repaired by making cement of celluloid and acetone. Dis olve the celluloid in acid until it is gummy hen clean seams and coat.

Cracked Compound.

Sometimes the tar composition material hat is on top of the cells cracks, and very often these become serious points of leakage of the cell solution. The best and simplest way to remedy them is to seal them together with a hot iron such as an old cold chisel or similar tool. Press the hot iron on the sides of the crack and gradually work them together until the hole is sealed over. If more of the tar material is needed, a big lump of it can be secured from a battery service station.

To Make a Battery Box Acid Proof.

Use 6 parts of wood tar and 12 parts resin, melt them together in an iron kettle, after which stir in eight parts of finely powdered brick dust. The surface to be covered must be thoroughly cleaned and dried before painting with this preparation, which should first be warmed.

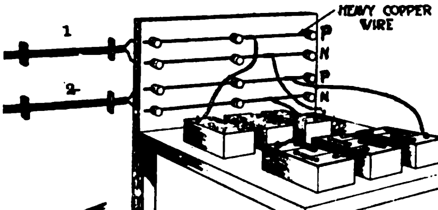
Spilled Electrolyte.

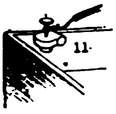
If there is evidence that electrolyte has been spilled from the cells, use electrolyte of 1.250 specific gravity instead of water to make up the loss.

After adding water, replace and tighten filling plugs by turning to the right and give the battery a charge at the proper rate for the type of battery as given in the table (page 467.)

Never add electrolyte to a cell after the gravity has been adjusted to the proper point, unless to replace actual loss by spilling.

Miscellaneous Hints.





No. 13

Fig. 11—A quick connection can be made from one battery to another by lightly driving a tack into terminals and using No. 18 steel wire. If an overcharge be applied—steel wire will heat and break.

Fig. 13—Simple method of connecting many individual batteries to one pair of supply wires. P and N are large bare wires. 1 and 2 are separate circuits. Smaller leads to individual batteries can be made. (Motor World.)

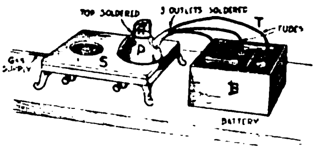


Fig. 23—A home made steam generator for softening the composition so that battery top may easily be removed. Consists of kettle (P), gas stove (S) and tubes (T). Steam is generated and passed into cells. The acid should first be removed.

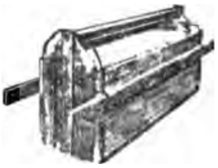


Fig. 24—Crating a battery for shipment; note shape in illustration. Inside di. should be 2" larger than battery and stuffed with excelsior. Label "handle with care—ACID."

*Prices to Charge and Addresses, Etc.

Price for charging a starting and lighting battery which includes testing......50c to $1.25

6 volt type.............	$ .50
12 volt type.............	.75
16 volt type.............	.85
18 volt type.............	1.00
24 volt type.............	1:25

These prices do not include changing of batteries. All changes not requiring more than 15 min. 25c. Batteries requiring more time to take out and replace, will be charged for at regular labor rates.

Price per day for rental of a battery in your car while your battery is being charged, 10c to 25c

Starter rentals will not be installed until generating system on car has been tested and we are assured that battery will receive proper charge while car is in use. A deposit to cover rental batteries is required.

Price for testing the electric system, other than disconnecting and connecting your battery, per minute ....1c to 2c

Price for repair work, per hour.....60c to $1.00

Notice—Storage batteries left over 30 days will become our property and will be junked without recourse.

The above is taken from a printed placard on the wall of a leading storage battery repair shop.

Where to Obtain Supplies.

It is best to order plates and parts of the manufacturer of the battery. Names of some of the concerns who handle supplies are:

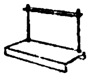
General Storage Battery Co., St. Louis, Mo. (supplies and parts of all kinds); **Meder-Staudt Co.** (supplies in general), 1904 Broadway, N. Y.; **Storage Battery Supply Co.** (supplies in general), 239 E. 27th St., New York.

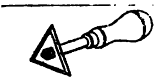
Address of Storage Battery Mnfgrs.

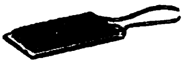
General Storage Battery Co., St. Louis; **Witherbee**—Meder Staudt Co., New York, N. Y.; **Exide**—Electric Storage Battery Co., Philadelphia, Pa.; **U. S. L.**—United States Light and Heating Corp., Niagara Falls, N. Y.; **L. B. A.**—Willard Storage Battery Co., Cleveland, Ohio; **Detroit**—Detroit Storage Battery Co., Detroit, Mich.

*Prices vary in different sections of the country. This is an example of prices charged by a concern in the West.

Battery Repairman's Tools.

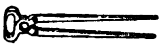

1


2

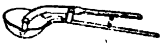

3

4

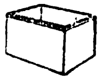
5


6

7


8

9


10

1—**Plate burning rack** which is used for burning post straps into plates and some means of burning—see page 472.

2—**Scraping tool** for cleaning parts to be burned.

3—**File card** for cleaning the particles of lead from the file.

4—**Putty knife** for scraping sealing compound.

5—**Element pullers** or regular gas pliers.

6—**Lead cutters** for cutting excess lead and for cutting post straps to necessary size.

7—**File for cleaning** lead before burning.

8—**Compound ladle** for melting the sealing compound.

9—**Hydrometer syringe** for testing electrolyte—(pages 453, 454).

10—**An acid tank**, lead lined for mixing acid, storing and soaking separators 24"x36"x24". **Separators** when new are usually dry and should be soaked in a weak solution of electrolyte before using.

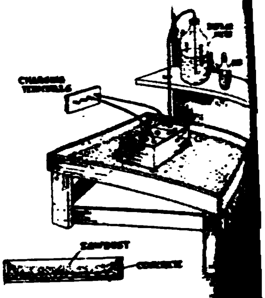


Fig. 21A.—Batt
By means of a sp
having a concrete
with sawdust, batt
rendered much
neater. The sawdu
absorbs any acid th
and turns black
ated, indicating that
renewed.

Supplies.

Compound for sealing jars and surrounding jars. This can be made of gum asphaltum 50 per cent, paraffine wax 25 per cent, and resin 25 per cent, melted together. Battery stations usually buy this compound in bulk.

Solution for making battery box acid proof, see page 478. This can

purchased at battery stations.

Electrolyte at 1.300 sp. gr. test should be kept in a closed stone or glass
Electrolyte is sold by manufacturers, see also pages 448-449. Electr
mixed with water to density required when using.

Distilled water. A supply should be kept on hand for battery use—see page 451

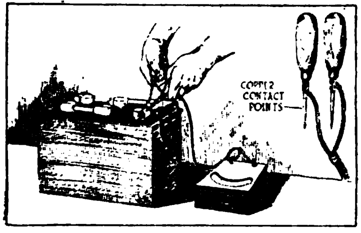
Extra battery connectors should also be kept on hand as well as other connections and parts such as extra jars, covers, vents, separators, etc.

Pure lead for burning connections together.

Thermometer for inserting into cells to test the temperature of the electrolyte.

Glass tube for testing the acid level, see page 455.

Volt-ammeter with a scale 0-30 volts and 0-3-30 amperes is indespensible to the battery repairman, see pages 414-416-398-453.



Voltmeter and copper contact points for testing voltage of different cells

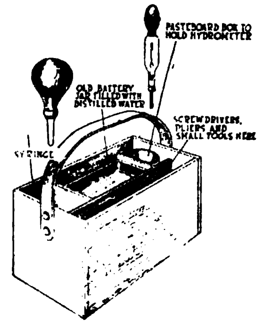
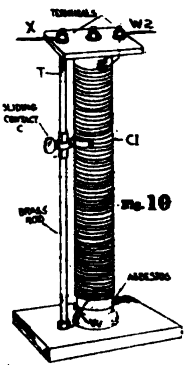
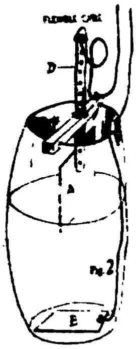

PASTEBOARD BOX TO HOLD HYDROMETER
OLD BATTERY JAR FILLED WITH DISTILLED WATER
SCREWDRIVERS, PLIERS AND SMALL TOOLS HERE
SYRINGE

Fig. 20A.—Battery service kit: A rectangular box is divided into four compartments, as shown. One contains the hydrometer, in a cylindrical pasteboard box for testing; the second contains distilled water, in an old battery jar for replenishing water; a third holds a syringe for placing the water in the battery. The fourth space runs the entire length of the box, and is used for miscellaneous tools, such as screwdriver, pliers, meter, etc.

Principle of a Rheostat or Resistance.‡





A rheostat is a device for absorbing some of the electrical pressure. In order to make current flow through a conductor, it is necessary to apply electrical pressure (voltage). The greater the pressure more current will flow.

For example—suppose you desired to charge a 6-volt storage battery from a 110 volt circuit. It would be necessary to absorb approximately 104 volts in some sort of **resistance** or **rheostat**. (see also page 464.)

This resistance could be lamps as per page 460; iron wire per fig 10; salt water per fig. 2.

***Iron wire rheostat:** Iron wire offers resistance to flow of current, therefore by using say—about 1/32" di. and wrapping it around an insulated cylinder, as porcelain or stone, and connect wire from 110 volt circuit to (X, fig. 10), the current would then pass down sliding contact rod (C). If one terminal of battery was connected at (W2) and other battery terminal to other connection of 110 volt line—this would form a circuit.

Now by moving sliding contact (C) down, more resistance is thrown into the circuit; by moving it up, less resistance will be in the circuit. This is the principle of a rheostat and is similar to "resistance units" shown on page 464.

A stove pipe, wrapped with asbestos and iron wire over that has been used.

Water rheostat; another way is to partially fill a 5 gal. stone jar with salt water (fig. 2). With one metal contact (B) in the bottom and the other (A), which is a sheet immersed more or less in the barrel. By movement of (D), the nearer plates are together—less the resistance. Further apart they are—more resistance, see pages 463 and 209.

CHART NO. 205G—Battery Repairman's Tools and Supplies. Principle of a Rheostat (Motor World.) See also pages 424, 410, 414 and index for "cadmium tests."

*Note that "direct" current is used and positive pole of current supply must connect with positive pole of battery. ‡See pages 209 and 463 for meaning of resistance.
See advertisement, Continental Battery Stand, back of book.

Fig. 1.

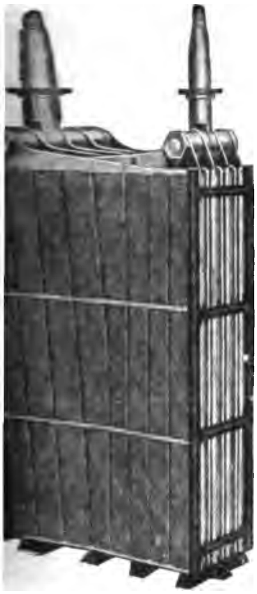


Fig. 2.

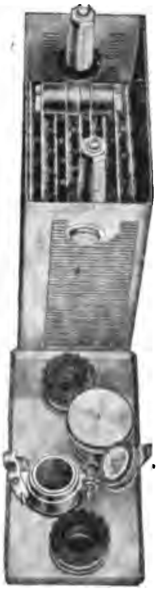


Fig. 2—Showing positive and negative plates of he A-4 Edison cell assembled together, but removed rom the container.

Fig. 3—Type A-4 Edison cell, showing the positive and negative plates in the container, and also he removed cover with openings. The retaining ar is made of sheet steel and electroplated with ickel.

The Edison Storage Battery.

The plates in the Edison battery are made of nickel and iron, the former in the form of a hydrate and the latter as an oxide.

The electrolyte is a solution of **potassium** hydrate (potash).

The positive plates consist of steel grids, which are nickel-plated; they are in the form of nets of 30 tubes per grid, each of which is filled with active material, the latter being composed of pure metallic nickel in the form of leaves or flakes. The pure nickel flake is produced by an electro-chemical process.

The negative plates are composed of 24 flat rectangular pockets, which are supported in three horizontal rows in nickel plated steel grids. These pockets are also formed out of thin nickel-plated steel and they are full of perforations. The active material in the pockets forming the negative element of the battery is oxide of iron.

Voltage—each cell delivers approximately 1.2 volts. Therefore 4 cells would be required to give six volts instead of the usual 3.

The advantage claimed by the makers is in the greater amperage. For instance, the claim is that with five of their cells, weighing less than three cells, the amperage, or quantity of current the battery will deliver will be twice as much as the three cell battery.

It is stated that the reason the Edison battery is not used for starting motor purposes is due to the fact that its internal construction is such that it cannot deliver the high discharge amperage suddenly, as required. It is capable of delivering a low amperage for a very long period, however.

The G. V. Electric Truck
is illustrated below and on pages 476 and 478.

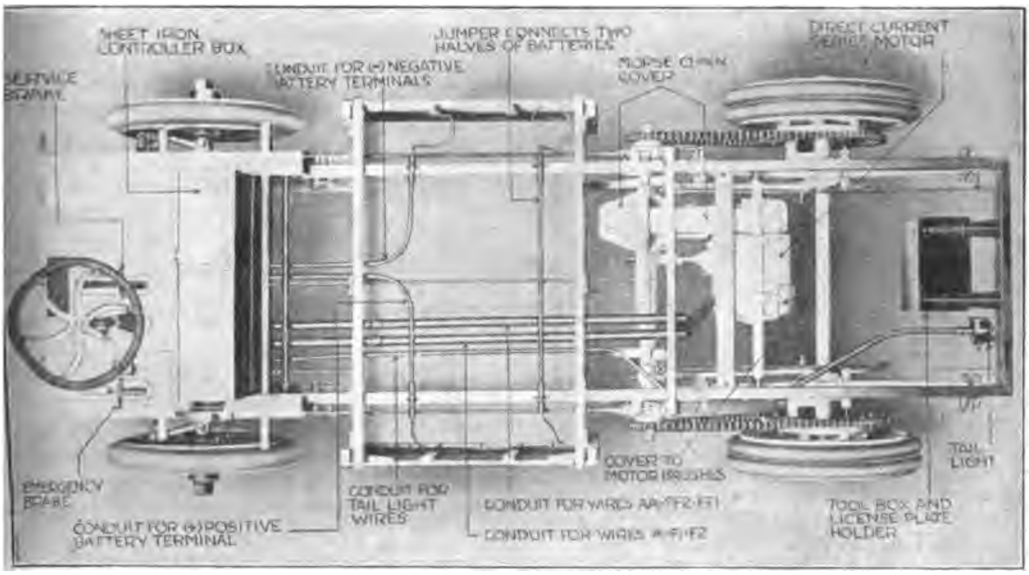

SHEET IRON CONTROLLER BOX
JUMPER CONNECTS TWO HALVES OF BATTERIES
DIRECT CURRENT SERIES MOTOR
SERVICE BRAKE
CONDUIT FOR (-) NEGATIVE BATTERY TERMINALS
MORSE CHAIN COVER
TAIL LIGHT
EMERGENCY BRAKE
COVER TO MOTOR BRUSHES
CONDUIT FOR TAIL LIGHT WIRES
CONDUIT FOR WIRES AA-FF2-FF1
TOOL BOX AND LICENSE PLATE HOLDER
CONDUIT FOR (+) POSITIVE BATTERY TERMINAL
CONDUIT FOR WIRES A-F1-F2

Fig. 1: Top view of G. V. 2 ton electric truck. The G. V. truck is made in 6 sizes; 1000 pound wagon is made with worm or chain drive; 2000 pound, chain driven; 2 and 3½ and 5 ton trucks are chain driven.

Specifica

Carrying capac tons; speed, m per hour 9; mi travel (approxi ly) on one ch 45; number of b teries 42; ampe (approximately) starting 75 to amperage when r ning 35; weigh truck including teries 6,395 pou weight without b teries 4,050 pou price (chassi $3,000; wheel b 112½"; track tread 61"; ove length 167"; ti (solid) front rear 36x3 du

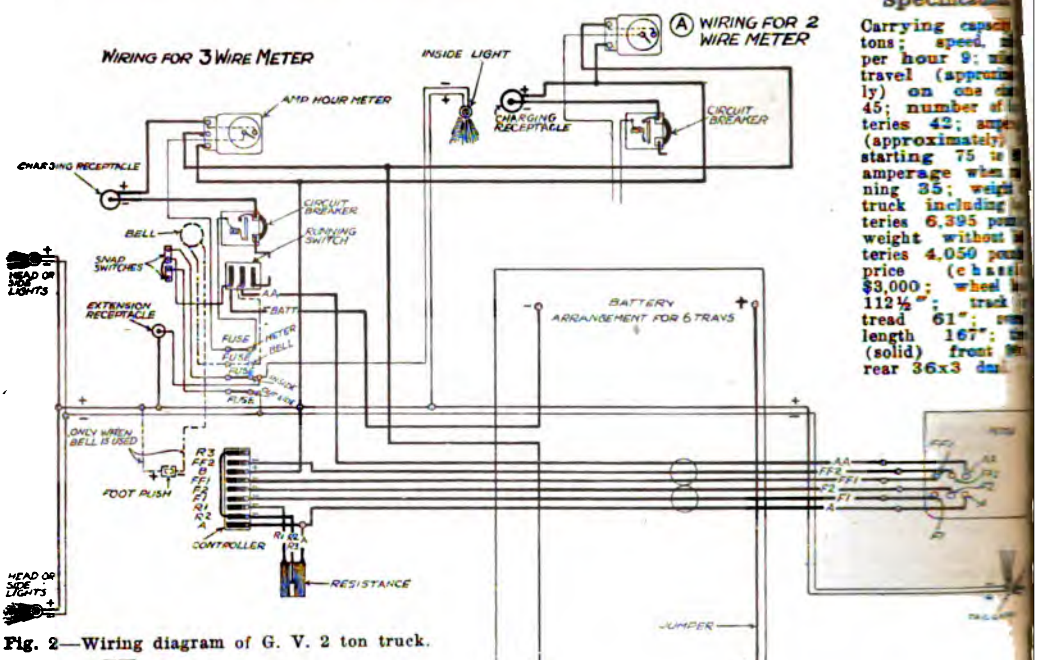


Fig. 2—Wiring diagram of G. V. 2 ton truck.

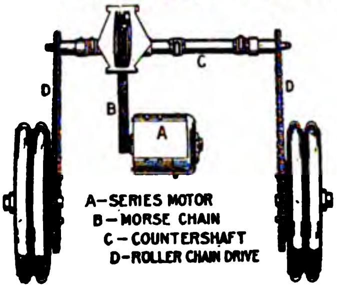


Fig. 3—Note the simplicity of the drive system—see also page 475.

Explanation of Parts of Electric Truck.

The controller box is placed in front convenient to the driver (see figs. 1 page 475, and 4). It contains the controller, resistance unit, fuse block switches, etc. The current is disconnected by the switch (fig. 4) which is a 3 way running switch and is thrown to the left when battery is being charged, to the center when current is off and to the right when running.

When charging battery—connection is made with "charging receptacle" (fig. 2) from an outside source of electric supply. In case the current charging battery should fail for any reason the **circuit breaker** (fig. 2) will disconnect so that current from battery would not flow back.

The ampere hour meter (fig. 2) shows the amount of current taken from battery when running.

When charging, a compensating shunt is used, so that the meter runs approximately 15% slow. The Sangamo Electric Co., Springfield, Ill., manufacture the meter used on this truck.

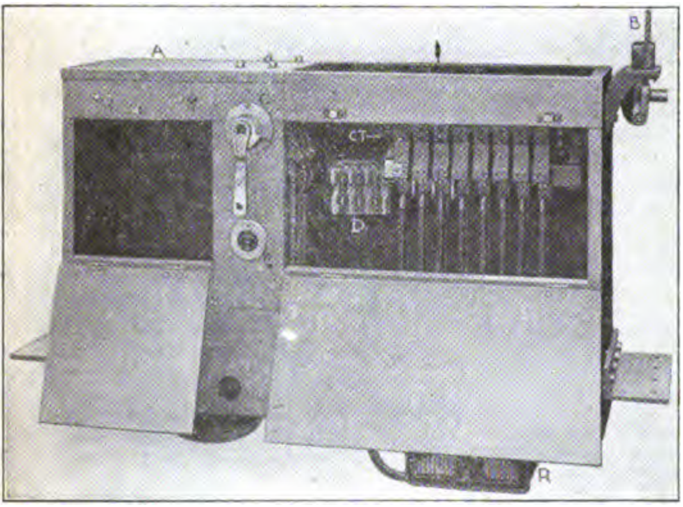


Fig. 4; Controller box. A—sheet steel controller box; **B**—controller handle; **C**—three way switch; **D**—lamp circuit fuses; **E**—plug for portable lamp; **R**—resistance.

CHART NO. 207—Electric Truck (General Vehicle Co.'s 2 Ton Truck as an Example).

Horse power of motor at 84 volts and 40 amperes is approximately 4 h. p. Starting cold, this motor will run 100 overload for one half hour and 200% overload for 10 min.

Wiring diagram above shows connections to be used for either differential shunted "three-wire" ampere-hour or "two-wire" ampere-hour meter equipped with variable resistor element.

INSTRUCTION No. 33.

*THE ELECTRIC VEHICLE: Electric Truck; Dual Power Cars; Gas and Electric. Electric Brake. Electric Gear Shift. Magnetic Latch. Couple-Gear Gas-Electric Truck. Four Wheel Drive. The Entz Owen Magnetic Electric Transmission of Power. Prest-O-Vacuum Brake. The Solenoid.

The Electric Vehicle.

Although this book deals principally with gasoline engine driven cars, a few words relative to the construction and battery connections of an electric vehicle will be given.

Electric vehicles are used to a great extent for pleasure cars and trucks. The objections to an electric pleasure car is the recharging of the storage batteries which prevents long country runs. The electric vehicle is a very simple proposition compared with the power plant of a gasoline vehicle and for city truck use is considered very serviceable, especially where a charging plant is convenient.

The electric vehicle is made up of three parts; a body; the chassis; and the motor, controller and batteries, or the power plant.

The power plant; an electric motor (series wound) and similar in many respects to the starting motor described in Instruction 26, is mounted to the frame, illustration chart 207 shows method of mounting the motor and driving by a chain, oftentimes a propeller shaft drive is used.

Average h. p. of motor for the electric pleasure vehicle is about 4. On trucks it varies as follows; ½ ton truck 3 h. p.; and 1 ton, 4; 2 ton, 5; 3 ton, 7; 5 ton; 10.

Batteries: It has become standard practice on pleasure vehicles to divide the battery, placing approximately half of the cells at the front end of the chassis on a rack level with the frame, and covering them with a wooden hood extending out in front of the dash or forward end of the body proper. The rest of the cells are placed in a similar position at the rear, where they are covered with a wooden boot. The hood and boot are either hinged or removable.

An example of placing batteries on a truck is shown in chart 207.

There are usually, 42 or 44 cells. Each cell gives two volts, therefore the voltage with all connected in series would be 84 or 88 volts.

On the truck shown in chart 207, there are six trays of seven 3-cell batteries. Therefore 42 cells, or 84 volts in series.

The amperage of the cells used on pleasure cars are usually from about 150 to 180 ampere hour.

Controller.

The controller in an electric vehicle performs practically the same function as the change speed mechanism in a gasoline car. It controls the flow of current to the motor, and so regulates the speed of the vehicle and the construction is similar to those used on street cars.

An electric vehicle, to maintain its rate of speed is dependent on the voltage and current output of the battery, as the energy required for maintaining this speed is measured in watts; i. e., voltage X amperes equal watts.

The nearer normal voltage of the battery under working condition, the nearer the maximum speed of the car. This is due to the fact that a motor in any given vehicle, is so constructed that for the armature to make its complete number of revolutions per minute a given voltage is required. This speed can be varied by introducing into the circuit a suitable amount of resistance. The effect being the lowering of the voltage delivered to the motor. As a normal voltage is required to maintain normal speed of the motor, it follows that the lowering of the voltage will be a corresponding lowering of the vehicle speed. This introduction of a variable resistance, together with the relative positions of the field windings of the motor, is accomplished through what is termed the controller. The changes in the various positions or speeds being accomplished without any break in the circuit, giving a steady gradual increase or decrease. In the General Vehicle Co.'s truck, page 476, the speeds (five forward and two reverse) are controlled by varying the resistance and in changing the position of the field windings (see page 478).

Amperes in Starting and Running.

When first starting the motor from a stand-still on a pleasure vehicle, the quantity of current used is about 50 to 60 amperes, after being in motion and on a level it will drop to about 18 to 25 amperes.

On a truck, say, ½ ton capacity, the amperage would probably go to 75 to 80 when starting and about 85 when running on a level.

The usual ampere-hour capacity of batteries for trucks range from 160 to 227 or more ampere-hours. The number of cells being 42 to 44. The horse power of the electric motor is usually 3 to 10 h. p.

The 42 or 44 cell battery will have the same ampere-hour capacity as a single cell, but of course the watt hour capacity increases in proportion to the increase in the number of cells and voltage.

Mileage and Speed.

The speed depends on the voltage or pressure.

The number of miles an electric vehicle will run depends on the size of the cells and amperage output (amperage means quantity), the larger the cell the more quantity of current it will deliver, but the pressure or voltage always remains the same, whether large or small

*If the battery gives 150 amperes for one hour, or one ampere for 150 hours, then it is called a 150 ampere hour battery.

If the motor on an electric vehicle requires, say 25 amperes per hour and your battery was a 150 ampere hour battery, then you could run your motor steadily for 6 hours and if your speed was 15 miles per hour you could make 90 miles—providing you were running on a perfectly level floor, but when you come to grades your motor will require more quantity of current or more amperage for a few minutes, or when starting off on a grade the motor will pull considerably more current from the battery. **Therefore the mileage is governed by the size of the cells and the current consumption.** A great deal also depends upon the driver, in how he uses his control as to current consumption.

Understand, the voltage of the vehicle battery when say, all 42 cells are connected in series, with motor, would give 84 volts Therefore if there was 15 ampere draw at 84 volt pressure—by multiplying the voltage and amperage together (15x84) we would get 1260 watts. 746 watts equal one horse power. A kilowatt is 1000 watts.

*Figures not accurate—used only as an example. There is a graduated loss governed by rate of discharge, see page 441.

A rectifier or charging plant for charging electric vehicle batteries should be one which will give at least 30 amperes and 110 volts or 3 kilowatts (a kilowatt is a 1000 watts.)

—continued from page 476.

The Controller

is used to make connections for the different speeds. By referring to fig. 4A, note the movement of lever for the 5 speeds forward and 2 speeds reverse.

The controller is of the "constant torque" type and batteries are connected in **series** at all times. The various speeds are obtained by cutting out or in **resistance** (cast iron) and also by **making** "field" connections of motor as explained below.

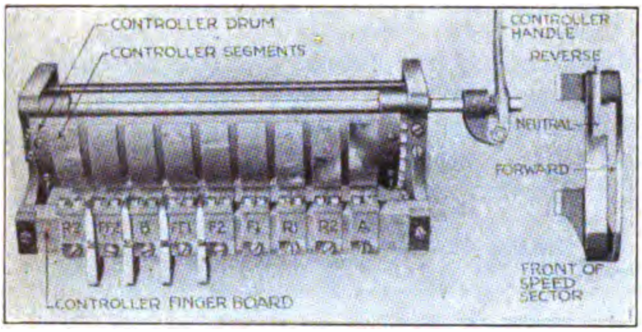


Fig. 4A: Controller—note connections of fingers, refers to diagram fig. 6.

Controller Connections.

By referring to fig. 4A and diagrams fig. 6 and 7 the connections from controller to resistance and field circuits can be traced.

R1, R2, R3—mean resistance; R1 all resistance is in circuit; R3 about one half is in; R2 about one third is in—see fig. 7.

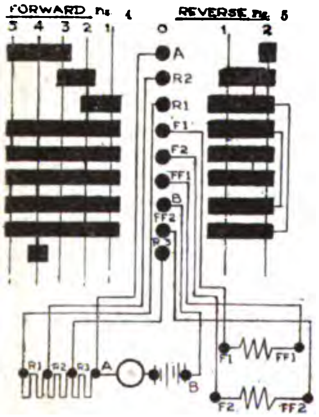


Fig. 6—controller connections: O—is off or neutral position. Black dots refer to controller fingers. Black squares refer to controller copper segments. The 5 speeds forward and 2 speeds reverse are shown.

F1 and F2 is one set of 3 field windings; FF1 and FF2 second set and are connected in series. The two windings are connected in series on speeds 1-2-3-4 **and in** parallel on 5th speed.

A1 and AA are to armature brushes; there are **two** brush holders with three brushes each, on motor.

In fig. 6, the letter "O" is the neutral or "off" position of controller, and the black dots refer to controller fingers.

Forward Speeds.

First speed; see fig. 7—(1 forward); both fields are **in** series and all resistance (R1) is in the circuit. **This is** the slowest speed.

Second speed; see fig. 7—(2 forward); both **fields are in** series and part of resistance is cut out (R2).

Third speed; see fig. 7—(3 forward); both fields **are in** series and all resistance cut out.

Fourth speed; see fig. 7—(4 forward); resistance (**R3**) **is** shunted across the series field.

Fifth speed; see fig 7—(5 forward); fields are in **parallel;** all resistance cut out.

The forward speeds are divided approximately equal, **each** notch of the controller being an increase of approximately 20 per cent in speed.

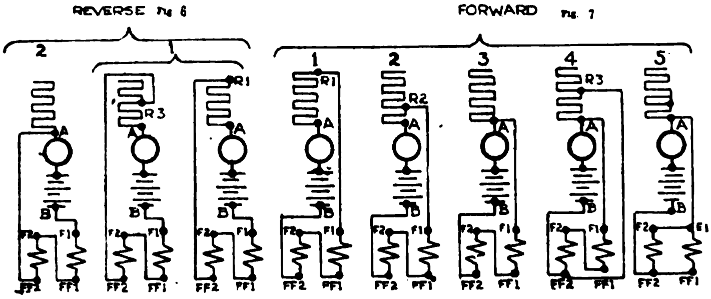
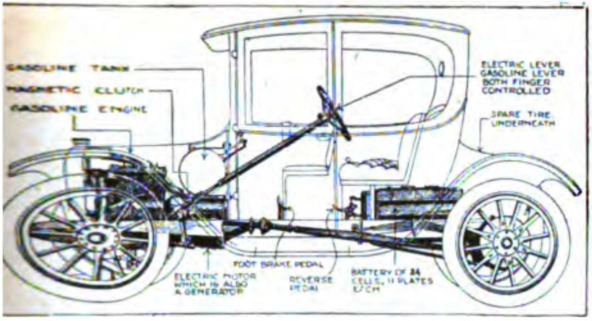


Fig. 7—Illustrating the resistance connections R1, R2, R3 and field connections F1 and F2 and FF1 and FF2. **A**—is armature brush connections; **B**—battery connections.

Reverse Speeds.

Reverse speeds are the same connections as second and third forward, but passing through first speed to prevent heavy rush of current. The direction of flow of current is changed **which** reverses the rotation of armature.

For resistance, cast iron is used.


GASOLINE TANK
MAGNETIC CLUTCH
GASOLINE ENGINE
ELECTRIC LEVER GASOLINE LEVER BOTH FINGER CONTROLLED
SPARE TIRE UNDERNEATH
FOOT BRAKE PEDAL
ELECTRIC MOTOR WHICH IS ALSO A GENERATOR
REVERSE PEDAL
BATTERY OF 24 CELLS, 11 PLATES EACH

Woods Gas-Electric Car.

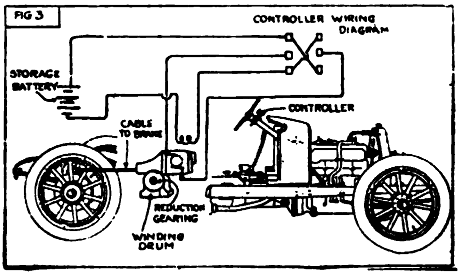
The Woods dual power car: The power plant consists of a small gasoline engine and an electric motor-generator combined into one unit, as illustrated, and mounted on a three point suspension. The movement of a finger lever on the steering wheel connects the engine to the electric motor-generator, which cranks the engine and develops power which is transmitted through the armature shaft of the electric motor and propeller shaft, direct to the rear axle.

The car starts as an electric, by a simple movement of a finger controlled lever on the steering wheel, which operates the means for connecting the battery to the motor and increasing the speed; as the lever is advanced.

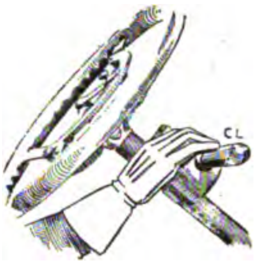
At any advanced position of the electric lever the first movement of the—finger controlled gasoline lever—instantly starts the gasoline motor. As this lever is moved forward it causes the car to be operated more on the gas, and at a certain point it will run as a straight gasoline car neither charging nor discharging the battery. With a slight variation of the relative position of the two levers on the steering wheel, the battery may be either charged or discharged at will on any speed from ten miles an hour up to twenty-eight or thirty miles an hour. Electricity is generated and stored in the battery while the car is running.

At any speed above six miles per hour, dynamic breaking may be effected by retarding the electric lever. This causes the electric motor to run as an electric generator driven by the gasoline motor or by the momentum of the car. The power thus generated is used for charging the battery. The same effect may be obtained by a simple movement of the foot brake pedal, which also acts as a mechanical brake below six miles per hour. (Woods Electric Vehicle Co., Chicago Illinois).

FIG 3



Electric Brake.



The Hartford braking motor is shown with reduction gearing. Armature shaft carries a worm gear which drives at a reduction of 100 to 1. This worm gear in turn operates a drum through an internal gear at a reduction of 4 to 1, giving a total reduction of 400 to 1. A steel brake pulling cable which is wound on the drum, transmits the pull of motor to brake mechanism.

The controller (CL) is moved by degrees which applies brake gradually; or suddenly if moved to extreme limit.

The point of decreased speed before coming to a full stop is illustrated by the fact that a car, moving at the rate of 50 miles an hour, or 73-1/3 feet a second, can within 35 feet, or in one-half second's time, be slowed down to 15 miles an hour or 22 feet a second, and brought to a dead stop within the next 10 feet.

Current required is 40 amperes for 2/5ths. of a second and a pressure of 6 volts.

Prest-O-Vacuum Brake.

By utilizing the suction in the intake manifold to exhaust the air from a cylinder (B) carrying a piston, the piston is forced to move, and in its motion applies the brakes through the usual braking system. The amount the brakes are applied depends, of course, upon the suction of the cylinder, and this is controlled by the driver through a throttle valve operated either by a pedal or hand lever.

Fig. 3 shows the general layout of the system when installed on a car. It will be noted that the forward end of the suction tube, is attached to the intake manifold at its junction (1) with the carburetor pipe, this being the point of most constant suction. From here it leads to the throttle valve (C) located convenient to the driver's foot.

The principle is similar to the air-brake cylinder used on railway trains, having a pressed steel shell, cast steel head, and carrying a pressed steel piston with leather packing. This piston has a diameter of 7 in., an area of 38½ sq. in. and a stroke of 4 in., the entire braking cylinder assembly weighing about 10 lbs.

The suction in the manifold (I) varies from 8 to 12 lbs. per sq. in. When the throttle valve (C) is opened wide, at least 10 lbs. per sq. in. suction is applied to the piston in the braking cylinder. Hence, the area of the piston being 38½ sq. in., a suction, or, to be more exact, a pressure, of 10 times 38½ or 385 lbs., is applied to the piston.

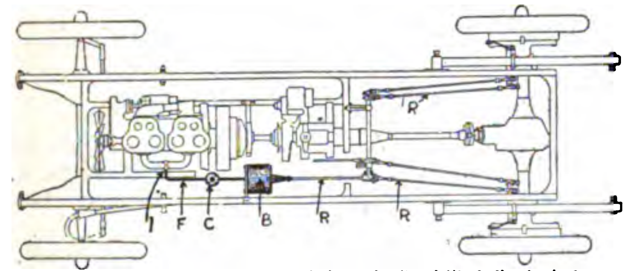
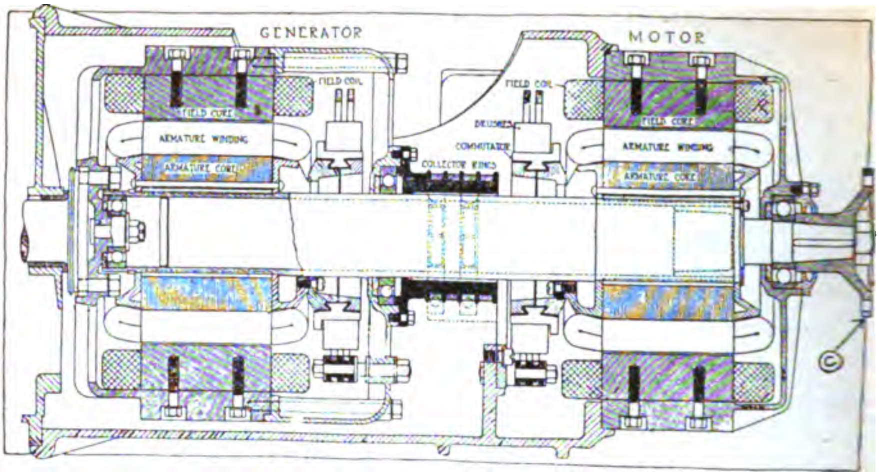


Fig. 3—Plan view of the system installed, showing its relation to the standard braking system

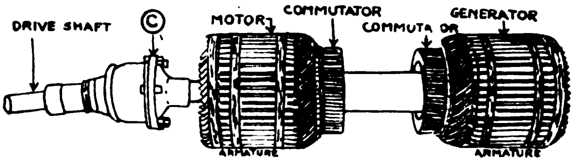
The piston, therefore, is moved under a direct pull of 385 lbs., and this in turn is compounded through the toggle joint connections to give a pull of 4000 lbs. on the brake rods. This is an extreme example of what the system can do, as a pull of 4000 lbs. is seldom required, unless on large trucks. It is evident that the pull applied to the brakes may be graded from 0 to 4000 lbs. at the option of the driver, the pull depending only upon the opening of the throttle valve. (Prest-O-Lite Co., Indianapolis Indiana, are the manufacturers.)

CHART NO. 207-B—Woods Dual Power Car. Hartford Electric Brake. Prest-O-Vacuum Brake.



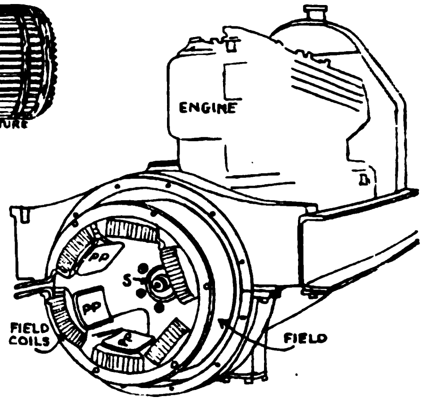
Section through Owen-Entz electric transmission. Generator field cores and coils form the gasoline engine flywheel and the collector rings shown are for the purpose of connecting the field current of the generator to the various circuits. The brushes of the generator revolve with the field. The two armatures are identical and both are keyed to the hollow shaft which is attached to the propeller shaft and has no connection with the gasoline engine

Electric Transmission.



Above—Armature of motor and generator attached to the propeller shaft as on the Owen magnetic car.

Right—Field coils, etc., of the electric transmission system forming the flywheel of the gasoline engine as mounted on the Owen magnetic car.



Explanation.

In place of the fly wheel, clutch, gearset, starting and lighting system and their auxiliary parts, two direct current dynamo machines and a drum controller have been substituted.

Clutch generator. One of the dynamo machines has its field magnet frame directly connected to the engine crankshaft, taking the place of the ordinary flywheel. The armature of this machine is mounted on a large, hollow shaft, which is directly connected to the propeller shaft. This machine is called the "clutch generator," as it acts both as a clutch and a generator. There is no mechanical connections between engine and rear axle; it is connected through an "air gap" which is entirely a magnetic connection.

The motor. The second dynamo machine has its armature mounted on the same hollow shaft as the first, and its field magnets are stationary; it is called the "motor," as it is generally used as a motor to help drive the propeller shaft, and boost the effort of the engine as transmitted through the clutch generator, which, like any clutch, can only transmit the engine effort or torque.

The clutch generator is used as a clutch alone, on the high speed, when it is short circuited upon itself, and a small speed difference between armature and field, or a small slip is necessary to establish the current in its windings which energizes it and causes it to act as a clutch.

On the high speed position the motor plays no part in the transmission of power, but is used as a charging generator for the storage battery, which later is used for cranking the engine and for the electric lights.

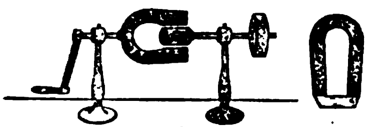
Electric motor aids propulsion. On all other power control positions but the high, the motor helps turn the propeller shaft, by taking current from the clutch generator in which circuit it is included. At these times the slip in the clutch generator is greater than needed to energize it as a clutch, and the additional slip produces the current required for the motor, which it utilizes for giving additional turning effort to the propeller shaft.

The different graduations of speed and torque are controlled by the relative strength of the generator and motor field. The weaker the generator field compared to the motor field the greater the slip and the more electrical energy goes to the motor for producing greater torque.

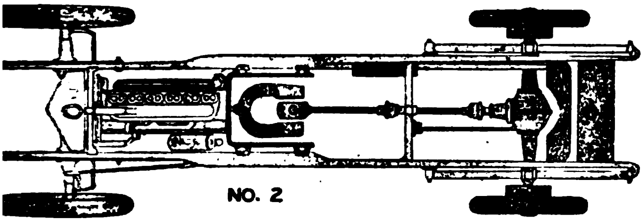
Besides the positions of power control, there is a neutral position in which the clutching effect is cut out, but the motor is so connected through a resistance as to act as an electric brake, in which case it becomes a generator, taking power to drive it, and so braking the car.

This brake is most effective when the speed is highest and is ineffective below 15 m. p. h.; it will hold the car on any mountain grade to 20 m.p.h. without wear of any parts and can be applied with the car going 60 m. p. h. It cannot hold the wheels and there is little danger of skidding, as the braking effort disappears at speeds below 15 m.p.h. (Automobile).

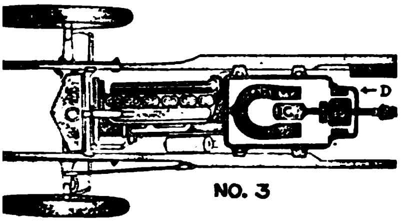
CHART NO. 207-C—The Entz System of Electric Power Transmission as Applied to the Owen Magnetic Car—continued on next page.



NO. I



NO. 2



NO. 3

Elementary Principle.

Illustration No. 1—A. Magnet with keeper familiar to everyone.

B. Magnet and pedestal with hand crank to revolve it.

C. Piece of steel on pedestal placed within magnet on same line of travel, it will be apparent that as the magnet is revolved by turning the crank it will attract the piece of steel which will revolve with it.

Illustration No. 2—B is now revolved by gasoline engine instead of hand crank, taking the place of the fly wheel as shown in chart 207-C and revolves at engine speed regulated by the throttle, and to accurately describe it, we will now call B a revolving field.

C is now part of propeller shaft, and to accurately describe this, we will now call C an armature, see chart 207-C, and when car is running in "high speed," C follows B, because it is magnetically locked, but it will be noted that we are **driving through an air space or gap**, there being no mechanical connection at any time between the rear axle and the gas engine, only magnetism transmitting the torque of the gas engine to the rear axle.

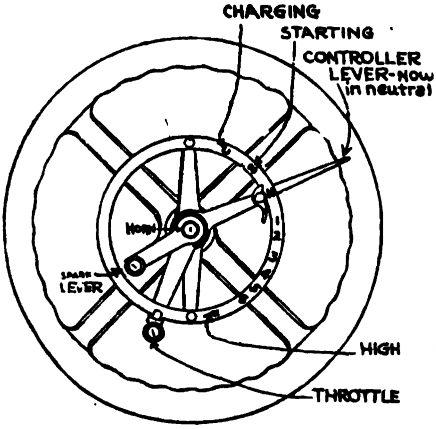
When arriving at a grade which is too steep to climb on "high," we would now stall our gas engine unless we applied a form of speed reduction.

Illustration No. 3—The conventional electric motor D, as shown in illustration 3, gives us the reductions needed in the following manner:

We now drive through what is in effect a slipping clutch, and it is apparent to us all, that if it were possible to use the power that is lost in heat through the friction of the slipping clutch in the old type gear transmission car, all the power of the engine would be transmitted to the rear wheels and there would be no use for a gear box.

The magnetic transmission gives us this result, as we now find that C is trying to keep up with B, but as B and C now have ceased to be magnetically locked, because we have changed the position of the control lever on the steering wheel, and therefore slipping, the difference in their relative speeds generates electricity which is led to D.

Armature E, being of the same form as C and on the same propeller shaft, see chart 207-C, takes the electricity generated by the slip, and acts as a power booster on the propellor shaft, giving us innumerable speed reductions, wonderful flexibility and absolute silence at all speeds.



Control Lever Positions.

Charging: Car stationary, engine running. Generator charging starting and lighting battery. Seldom necessary, as battery is automatically charged on high speed position when car is in motion.

Starting: Current from starting battery operates generator as a motor for starting engine. When engine has started, bring lever to neutral position.

Neutral: Car stationary, engine running. Clutch generator circuit is open, and motor is short circuited on a resistance. Bring lever to first position.

First position: Generator producing light clutching effect and maximum current for electric motor result—maximum difference between engine speed and car speed, and producing greatest torque or pulling power.

Second position:. Clutching effect of generator increased and current supply to motor decreased. Result—car speed increased.

Third position: Clutching effect of generator further increased and transmitting more of the driving power. The motor does corresponding less work, Result—increased car speed.

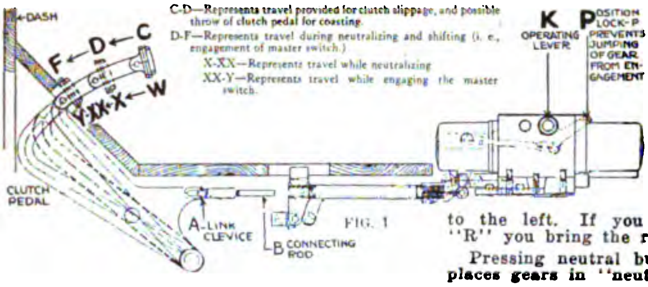
Fourth position: The generator continues to transmit more and more of the driving power—the work of the motor gradually decreasing. Result—car speed increasing.

Fifth position: Same general action. The generator carrying nearly all the load, while motor is practically idling.

High: On this position the generator clutching effect has increased to nearly locking point, transmitting all the driving power. Motor no longer assists, but operates only as generator to charge starting and lighting battery.

The gear ratio on the Owen magnetic car, 7 passenger is 4½ to 1 and on the 5 passenger car 3½ to 1.

CHART NO. 207-D—Owen-Magnetic Power Transmission System. Manufactured by General Electric Co., Ft. Wayne, Ind., and used on the Owen Magnetic Car, manufactured by R. L. Bake Co., Cleveland Ohio.



C-D—Represents travel provided for clutch slippage, and possible throw of clutch pedal for coasting.
D-F—Represents travel during neutralizing and shifting (i. e., engagement of master switch.)
X-XX—Represents travel while neutralizing
XX-Y—Represents travel while engaging the master switch.

FIG. 1

Magnetic Gear Shift.

Principle—If you press the switch button 1, (see fig. 2), you close the circuit of solenoid 1, causing the shaft (A) to move to the left.

If you press button 2, you energize solenoid 2, causing the shaft (A) to move to the right.

If you press button 3, you energize solenoid 3, causing shaft (B) to move to the left. If you press button "R" energizing spool "R" you bring the reverse gear into mesh.

Pressing neutral button N and throwing out the clutch places gears in "neutral."

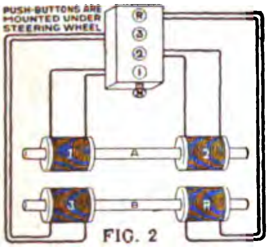


FIG. 2

Pressing a push button does not energize one of the solenoids, it merely partially closes the circuit to a certain solenoid but the circuit is not completely closed until you **throw the clutch pedal down to the floor-board.**

The clutch pedal is so arranged that you can throw out the clutch in the usual manner by **partially** depressing the pedal, but if you push the pedal to the extreme position you bring the switch (M) fig. 3, in contact for an instant and permit the electricity to flow to the particular solenoid which was selected when you pressed one of the push buttons.

The push buttons are therefore known as "selector switches" because they do not actually close the circuit but select in advance the circuit that will be energized when you push the clutch pedal to the extreme position, thereby closing switch (M).

A 12 volt battery is used—it is stated an 80 ampere hour battery will operate the gear shift from 394 to 491 times.

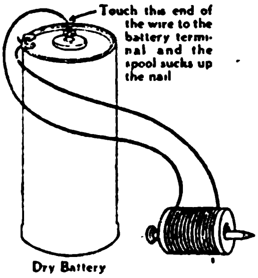

Touch the end of the wire to the battery terminal and the spool sucks up the nail
Dry Battery

Fig. 4. Principle of a solenoid, simplified.

Gear Changes.

First speed:—To start forward in first speed, push "selector switch" *button* No 1 down until it catches. Then depress clutch pedal as far as it will go and first speed gears will instantly mesh. Allow clutch pedal to return gently. The clutch will engage and the car move forward in first speed.

Second speed:—Press button No. 2 until it catches and as soon as it is desired to shift the gears from first to second, depress the clutch as before to its extreme position. This brings the second speed gears into mesh. Engage the clutch.

Third speed:—Press button No. 3 until it catches. Depress the clutch to its extreme position. Allow clutch to return to engagement.

Dropping back:—In dropping back from one gear to another, the operation is the same, i. e., press the button corresponding to the gear wanted, and when it is desired to shift, simply push the clutch to the extreme limit and the gears will automatically change.

Selection:—Should button No. 2 be depressed and should it then be decided that No. 1 is wanted instead, all that is necessary is to press button No. 1. This automatically "kills" No. 2. Similarly, any button that is down is "killed" by pushing any other button. The gears may be selected in any order desired, for example—1 to 3, 2 to 1, 3 to 1, etc. It is not necessary to press the buttons in numerical order.

Pre-selection:—Speed changes may be prepared for at any time in advance of the actual shift by pressing the button corresponding to the gear into which it is next desired to shift.

When the car is stopped, the gears should always be neutralized before the driver leaves his seat, so that when the motor is again started, none of the gears will be in mesh.

Neutralizing:—To throw the gears to neutral, press the "N" button, and then depress the clutch pedal to the limit. (The neutral button has no catch and does not remain down when it is pressed. Its function is simply to throw out the other buttons in order to break their electrical connections.)

Coasting:—The clutch pedal may be thrown out far enough to free the clutch without neutralizing or shifting the gears. The shift takes place only when the pedal is thrown to the extreme position. This arrangement permits disengaging the clutch so the car can "coast," no action taking place in the gear shift. See fig. 1.

A—gear shift housing.
B-1-2-3-4—coils.
C-1-2—magnet cores.
E-E—cam shafts.
F-F—neutralizing cams.
G—ratchet pawl lever.
I—rocker arm.
J—operating shafts.
K—operating lever.
L—p a w l operating master switch.
M—master switch.
N—locking shaft.
O—master switch return spring.
P—neutralizing return spring.
Z—neutralizing return spring shaft.

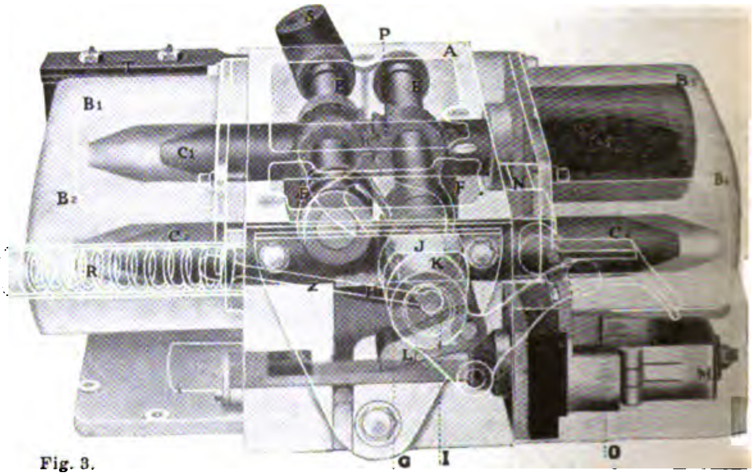


Fig. 3.

CHART NO. 207-E—The Magnetic Gear Shift. This device is used to shift the gears, taking the place of the hand shift lever and selector rods, as explained on pages 48 and 49. It is attached to the side of the transmission. **The switch** control is placed under the steering wheel. **This system is used on the** Premier Car. (Above device manufactured by Cutler Hammer Co., Milwaukee, Wis.)

The Magnetic Latch Used on The 1914 Cadillac-Delco Starting System.

The Clutch Pedal is connected with what is called a magnetic latch. The clutch Pedal can be operated as usual for throwing in and out the clutch, and when used for this purpose C & B are not in contact.

In Starting the Engine with starting motor, the "start" button is depressed but at the same operation the current is caused to flow around the coil on the magnetic latch. The lever (C) is pulled to the core (H) by magnetism—this action places C then, in the line of path of B and the result is, the rod (A) shifts the starting motor gears as by hand lever

The Clutch Pedal operates free of (C) as the spring pulls (C) out of the path of B during other operations of Clutch Pedal. Thus it will be seen that the clutch pedal and starting button are used for starting per fig. 1.

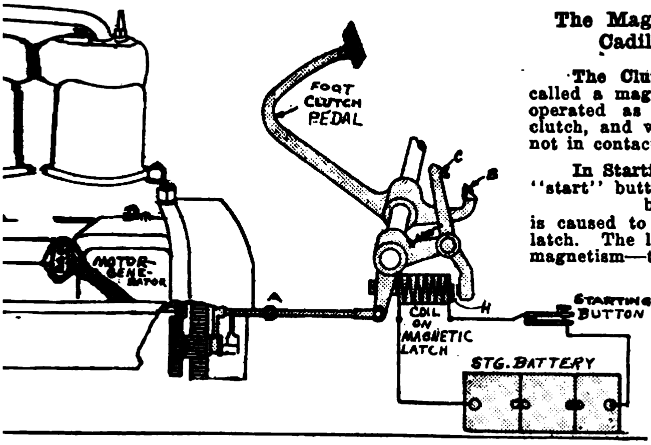


Fig. 1—On the 1914 Cadillac There is a Magnetic Latch used connection with Clutch Pedal to shift gears for starting on the lco starting system.

The Magnetic Latch used on the 1914 Cadillac, Two Speed Rear Axle.

The Usual Type of Selective Transmission is Used, but instead of driving the rear axle through a single bevel gear and pinion, there are two gears and two pinions.

Gear L and Pinion L1 Mesh as the Low Direct Drive, which is 3.66 to 1 and is especially adapted for city driving, where starting, stopping and slowing down are frequent and where cautious operation is necessary.

Gear H and Pinion H1 Mesh for the High Direct Drive, which ratio is 2.5 to 1. This gear is used where speeds of 16 miles or more per hour is desired.

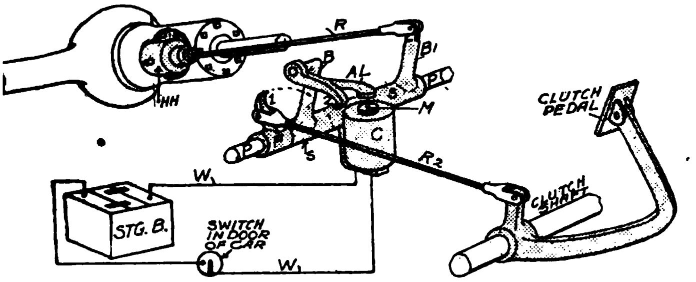
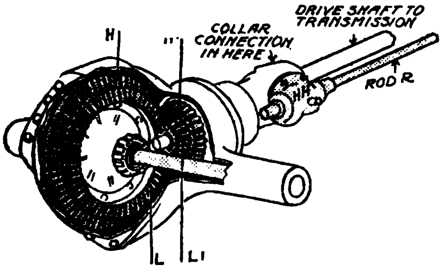


Fig. 2—There are two Magnetic Latches combined; one placed under the other, with two rods (R2) running to Clutch Pedal. One makes connection to shift L & L1 on the forward movement, and the other on the backward movement connects H & H1.



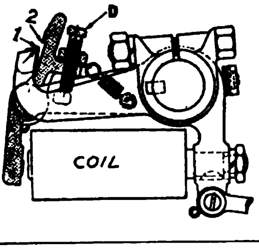
Either One Can be Connected With Drive Shaft, but in connecting one, the other is idle—for instance L & L1 work together or H & H1.

The Method For Making the Change is Done by a Magnetic Latch, on a similar principle as described above.

The Operation is as Follows: If it is desirable to have L & L1 (low gear in) then the switch on the door, is turned to the right, and down. This sends current from the storage battery through winding in coil (C). The magnet armature AL is drawn to magnet (M) causes the rod R to shift the collar in housing HH, which connects the gears L & L1 on the forward movement and H & H1 on the backward movement.

Now, When Clutch Pedal is Pressed, the Trigger 1 Catches the Latch 2 and pulls the entire apparatus which is on a sleeve (S). Therefore pressure of clutch pulls the rod (R) and shifts a coupling connection in the housing (HH). Note the trigger 1 works independent on the shaft P, as it is on a sleeve (F) free from (S). Therefore, if the magnet armature is not down, then clutch can work independent of the latch (2), as it will miss the latch and follow the dotted line. In this case clutch pedal operates this device only when the switch is turned for the purpose.

To Change to Other Gears H & H1, there is another magnetic latch (not shown in illustration) placed on the same sleeve (S) but Directly Under this one and the same operation is repeated. Therefore, there would be another rod to clutch pedal to connect to another trigger to shift coupling for H & H1. Being placed underneath, the same forward pull on the clutch pedal would "push" rod (R) back instead of forward. There is but one rod (R) used however. The motion of shift for H & H1 is just opposite to the pull of L & L1.



The advantages of the high direct drive gear ratio lie primarily in the fact that with it, any given speed of the engine produces an increase of about 42 per cent in the speed of the car. For example; at an engine speed of 700 revolutions per minute, with the low direct gear engaged, the car will travel approximately 21 miles per hour; while on the high gear it will travel approximately 30 miles per hour with no increase in engine speed.

Adjustment of Magnetic Clutch Arm.

The magnetic clutch arm (2) should be so adjusted by the adjusting screw (D) that the arm (1) will pass the arm (2) just allowing the point indicated by the arrows to clear each other when the main clutch is disengaged, and when the magnetic latch is in the disengaged position. Screwing up on the adjusting screw (D) decreases the distance between the points (1) and (2), and unscrewing the adjusting screw (D) increases the distance between these points.

CHART NO. 208—Principle of the Magnetic Latch on the 1914 Cadillac. A Delco System.

NOTE—The drawings are not drawn to scale but are exaggerated in order to simplify the principle. Althou the system is out of use, it is shown in order to explain the principle.

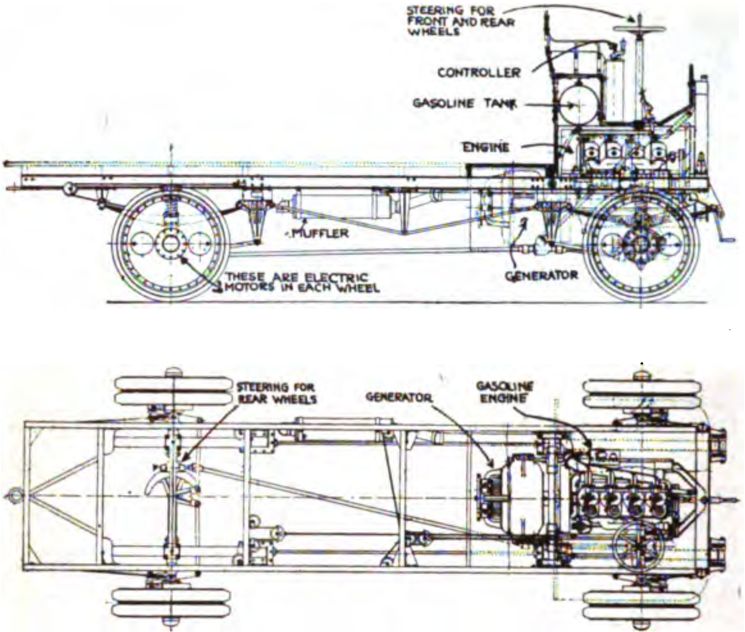


Fig. 1—A couple-gear four wheel drive and four wheel steer Gas-Electric motive power truck. Especially designed for suburban and other long distance work. Made in 3½, 4, 5 and 6 ton capacity.

Gas-Electric Truck

A very unique and s isfactory combi Gas-Electric power tr is called the Couple-G

The drive system is b means of an electric m tor in each wheel a shown in illustrati fig. 2. This would b termed the transmissi

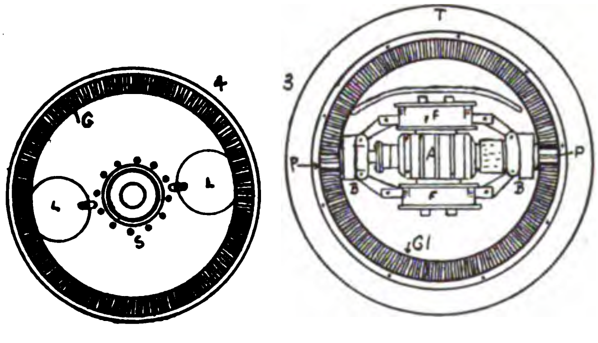
This gives a fo wheel drive and fo wheel steer witho complications. No un versal joints are used i the drive. All chain sprockets, clutches, slid- ing and reverse gears ar dispensed with.

"Couple-gear" trans-mission consists of an electric motor in each wheel, the motor arma-ture having a pinion a either end, one pinion pulling up on one side of the wheel, the other pulling down at the op-posite side, and both working at the periph-ery, (fig. 2). An "evener" device per-mits of compensating movement and divides the force "equally" be-tween the two pinions for unequal wear or ad-justments.

The gear reduction is 25 to 1 direct, and is supposed to deliver 97 per cent, of motor energy to the rim of wheel. Tires are solid 3½x36".

The power plant; is self-contained and consists of a gasoline engine connected to an electric gen-erator. The speed of the generator, controlled by the speed of the engine governs the speed of the electric motors in the four wheels. The engine is equipped with Bosch ignition, Stromberg carburetor. 2¼-inch five bearing crank as shown on page 80 fig. (4 S).

Generator—is designed especially for this class of work. The generator is rated 12½ K. W. at 100 volts, 680 revolutions per minute and will run completely sparkless with an ampere load 200 per cent in excess of its normal rating and with a 100 per cent rise in speed. The voltage at the maximum speed can be held down as low as 40. It is a six pole machine, with the same number of commutating poles, com-pound wound with a dropping characteristic, which automatically assists the engine to hold or increase speed at approximately the same rate as the increase in power is demanded for the vehicle propulsion. It is equipped with rheostat connected to fields by means of which the operator may raise or lower the gear ratio at will. Voltage can be held down to 40. Voltage drops when amperage exceeds 70. Weight 765 lbs., (see instruction No. 27, for principle of electric generator.) **Engine**—4 cylinder 5" bore x 5½" stroke.



Control.

Throttle, operated by foot lever. Igni-tion, fixed. **Motors** are operated either in series, series parallel or parallel which is governed by a controller of street rail-way type. Reverse lever, also on con-troller giving same range of speed back-ward as forward, and also operates as electric brake. **Speed;** from 7 to 15 miles per hour, 12 loaded, 16 miles without load.

Fig. 2; shows front disk and side of motor removed, giving access to the arma-ture, field coils and bearings. It will be noted that the electric motors are mounted in the wheels which is the method of transmitting the drive power. 33 ampere 80 volt motors are used in each wheel.

T—rubber tire; F—field winding; A—armature; B—armature bearing; P—pinion (gears which drive G1); G, G1—gear in wheel; 4—steel band for tire; L—wheel inspection door; S—roller bearing.

Motor is suspended by half of motor casting, which is a heavy stub, which passes through the knuckle shaft, making the motor frame itself a component part of the axle. The armature is carried rigidly within motor frame. The wheel shell then revolves about the motor frame. on roller bearings, one of which is at the rear of frame (3) and the other in frame (4). A cover which fits over armature (A) carries the bearing for (3), but is not shown.

CHART NO. 209—A Gas-Electric Combination of Power and Four Wheel Drive and Steering.
(Couple-Gear Freight Wheel Co., Grand Rapids, Mich., Mnfgr's.)

INSTRUCTION No. 34.

PERATING A CAR: Preparing a Car for Service. Starting the Engine. To Start the Car. Speed Changes. Running a New Car. Hill Climbing. Points to Remember. Skidding. Importance of the Clutch. Pointers on Steering. Pointers on Changing Gears. The Control Levers and Pedals. Gear-Shift Lever Movements of Leading Cars. Dash or Instrument Board of Leading Cars. How to use the Brakes.

*How to Operate a Car.

In learning to operate an automobile, the first step is to become familiar with how to start and stop the engine and the control of the speed, which can be learned best with the engine running.

The simplest way in which this can be done is to jack up the rear wheels so that they are clear of the ground, letting the weight of the car rest on a solid box. The point is to get the driving wheels clear of the ground, and free to revolve without moving the car.

The different speeds may then be handled, and the movements of the levers and pedals gone through with, without being under the necessity of steering, the steering being the simplest and easiest part to learn. Care should be taken to block the front wheels so that the vibration of the engine cannot shake the car from its support.

Lever Systems.

There are three types of side lever systems; the type which operates the planetary transmission gears, the type which operates the old-style progressive gears and the type which operates the selective type of gear.

†**The planetary gear type** is used on the Ford car and is very simple. See Ford instruction.

The progressive gear type is now seldom used. Its principle and operation is shown on page 46.

The selective type is the type used mostly and it is with this type we shall deal with principally. This type is shown in chart 212, also page 48 and 49.

****The gear shift lever used with a selective transmission**, is constructed in two types; the "gate" type and the "ball and socket" type, page 49. Also chart 212.

The emergency or hand brake lever, is usually placed along side of the gear shift lever. Sometimes these levers are placed on the side of the car, but more commonly found in the center as per chart 210. For a further description of the selective lever operation, see page 49.

Pedal Systems.

The "running" or "service" brake is a pedal operated by the right foot (see chart 210). **The clutch pedal** is a pedal operated by the left foot.

The accelerator is usually placed between the two pedals, as shown in fig. 2.

The movement of the gear shift lever for changing the gears, vary on different cars, as will be noted in chart 214. The principle or purpose however, is the same on all cars.

The spark and throttle levers are in most instances, placed on the steering wheel. On a few cars, they are placed under the wheel on the steering post. The throttle lever is usually the longest of the two. The movement of the throttle lever, whether up or down to open the throttle is easily determined by noting the movement of throttle on carburetor, the spark lever for advancing, can also be determined by noticing the direction it moves the timer or interrupter on magneto. Usually the **throttle** and **spark** lever are pushed **up** to open and to advance. See chart 213.

---

*If you have Dyke's Working Models of the 4 and 6 cylinder Engines, place Chart of Gear Box in connection with the model of Engine and note the relation of parts.

**See supplements. †See also Ford supplement.

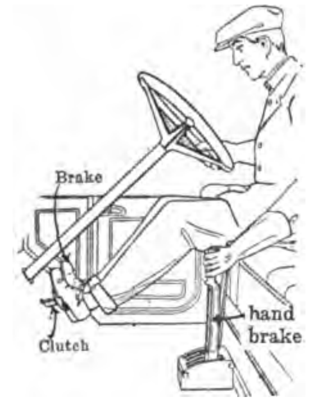


Fig. 1. See that gear shift lever is in "neutral," before starting. Release hand brake, then throw clutch "out."

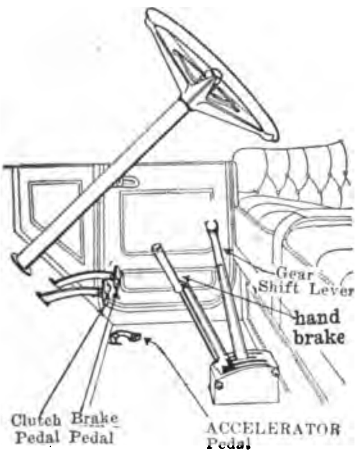


Fig. 2 Place gear shift lever into first or low speed position, after engine is running—but hold clutch "out" while shifting.

To Start Car.

Release the hand emergency brake: By pushing down on the ton on top of lever to the left of the gear shift lever (fig. 1), at the same time pull back slightly to release latch, then forward as far as possible. **Caution:—Never try to start car** the hand brake set.

Throw out clutch: The foot pedal to the left operates the Push the pedal as far forward as possible, to disengage the and stop revolving of transmission gears. (See page 41).

*Gear Changing.

First speed or low gear: With the clutch still disengaged, the gear shifting lever (now in "neutral" position in fig. 2), the left hand and pull sideways towards you. Then with a sharp motion move it into first gear. (Study the numbers cating speed changes in chart 212, and page 49). Now slowly lease the pressure on the clutch pedal, letting it back gently. car will then start ahead.

When the clutch is being engaged, the increased work on the engine will cause it to slow down. Therefore, at the time the clutch is being engaged gradually give the engine more by advancing throttle lever or pushing down on the accelerator If you fail to open the throttle as the load is thrown on the it is very apt to "stall." Remember, never try to shift gears out first disengaging the clutch. (See page 41).

Continue to run the car very slowly on first gear until come accustomed to the sensation of driving and have mastered operation of the steering gear. It is advisable to form a good of where the front wheels of the car are going to ride over the ahead of you. As you sit in the seat and are driving along a car track, the wheels will fit the rails—one wheel on each rail. sight ahead across the radiator, mud guard or hood, and set imaginary mark there somewhere exactly in line with the rail as passes under the machine. Riding in car tracks is bad for tires, try the same thing on country roads when you are compelled to in deep ruts—become familiar with where the wheels of your car going to run and you will then be surprised to find how easy to judge distances—in passing other vehicles, missing stones holes in the road, etc.

Second speed or intermediate gear: When you desire to go second speed, push down on the clutch pedal quickly, and hold so for a second and at the same time, with a quick, firm ment, pull the gear lever straight back, into neutral position, then push sideways, that is away from you and pull straight back forward which ever the case may be) into second speed, again gaging the clutch gently, and at the same time accelerating the engine when the clutch begins to take hold.

Third speed or high gear: In going from second to third speed, release the clutch as previously explained, and push the gear lever straight forward (or backward) into third speed, and again engage the clutch gently; accelerating the engine when the clutch begins take hold.

Most of the running of a car is done on the high gear. The starting of a car is always done on the low gear.

Regulate Spark.

In cranking, the spark was fairly well retarded, but since running on retarded spark for any length of time will cause the engine to overheat, the spark should be advanced as far as possible without causing a knock. Try for yourself the change that the time of spark makes in the running of the engine. Retard the spark and with the throttle opened so that the car is moving eight or ten miles an hour, gradually raise the spark advance lever. You will note that the car would gain speed and you will be able to draw the conclusion that by using the same amount of gasoline with the spark advanced you will be able to get a greater mileage per gallon of gasoline. Consequently always use as much spark and as little gasoline as possible. The general rule is that as the engine is speeded up, the spark lever should be advanced and as it is slowed down it should be retarded.

To Reverse Car.

Never attempt to reverse car when moving forward. Bring the gear shift lever into neutral position and pull it towards you and then straight back into reverse gear. Let the clutch in very slowly and the car will move backwards.

To Stop Car and Engine—see page 489.

*Gear changing position varies—see chart 212. Also chart 228 "Standard Adjustment of Leading cars."

CHART NO. 210—Starting Car and Changing Gears—see also pages 50 and 51.

Preparing Car for Service.

See that tires are properly inflated—see struction 41 "inflating tires."

Fill radiator with pure water—if freezing ather, use a "non-freezing" solution—see ge 193.

Fill oil pan of engine with good grade of linder oil—until gauge shows full—see pages 203 and 204. The oil is poured into engine through breather pipe, see upper illustration, page 71 for location of "breather."**

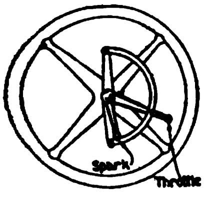
Fill grease cups—as per page 204, and see that all **wire connections** are tight—and also make sure that there is **gasoline in the tank.**

*Starting Engine.

Place gears in neutral: Be sure that the ear shifting lever stands vertical, so that o gears are engaged—see page 46.

Set hand throttle lever: The throttle is losed when the lever is down and opened when it is at the extreme top (varies; but his is general practice).

When starting, the lever should be raised bout one and one-half inches from the lowest position. (This varies on different cars.) See chart 213, and page 153.



‡When starting the engine, "retard" the spark lever to its lowest position. After the engine has started, "advance" the spark lever half way, and leave it there while shifting gears.

As a general rule, the spark lever should be advanced farther for fast driving than for slow driving, and especially should it be retarded for heavy, sandy, or up-hill roads when the car is running slowly and the engine laboring. When using the low or intermediate gears on the hills or in the sand the spark lever may be advanced farther than when using the high gear.

When driving over smooth, level roads, carry the spark lever advanced three-quarters of the way up the sector for speeds between fifteen and thirty miles an hour. For speeds above thirty miles an hour, carry the spark fully advanced, that is at the extreme upper position.

Never attempt to accelerate from slow to high speeds, in high gear, without first retarding the spark to the half-way position.

When attempting to pull slowly through deep sand or to go slowly up steep hills, in high gear, carry the spark not higher than the half-way position (also see chart 213).

Set carburetor air regulating handle (if one is provided): The handle usually on steering post or elsewhere (see page 159) controls the quantity of air supplied to the carburetor. When starting in cold weather, close the valve. This causes a rich mixture to be drawn in and less air. By a little experimenting you will be able to ascertain the best position for warm weather starting on your particular car.

Put switch key in place: The switch is usually located on the dash cowl. Insert the key as far as possible and give it a quarter turn. When released it will lock itself into position.

Crank the engine with starter: If a starting motor is provided, push the switch down as far as it will go with a firm unhesitating movement. Electrical connection is now made between the battery and starting motor and you can hear the engine turning over. Hold the switch down. In an instant the sound will change and the engine will then be running under its own power.

Important:—Just the moment the engine starts remove your foot from the starting switch and be sure that the lever springs back into its original position.

The time required for the operation varies from one-half second under good conditions when the engine is warm, to from five to ten seconds for cold weather starting. If the engine does not start within the mentioned time, release the starting switch, since you will know that something is out of adjustment and you are throwing an undue strain on the battery. (For full explanation of operation and care, see the starting motor instructions, referring to the type of motor system, cars are equipped with, in **Instructions 25 and 26**).

Regulate air to carburetor: When the air regulator handle (see page 159) is on the starting line, the air is practically shut off from the carburetor and the engine is drawing a mixture which is very rich in gasoline. A rich mixture aids in cold weather starting and the car can be driven immediately after the engine starts without waiting for things to warm up. However, a rich mixture consumes an excessive amount of fuel, is conductive of overheating and causes undue carbonization of the engine parts. Consequently, until you can get the engine to run on hot or cold air, open the air regulator to carburetor gradually to the left and leave in a position where it does the best work. Remember that air is cheaper than gasoline therefore run with as much air as possible, and slightly advance spark lever.

Close hand throttle: Do not allow the engine to race, i. e., run very fast without load. Move the throttle lever down until engine runs at fairly low speed. When leaving the car with the engine running the throttle should be entirely closed. With a little experience you will be able to ascertain for yourself the best position of the engine control parts for your particular car.

Test accelerator: Before attempting to put the car in motion, acquaint yourself

---

*See foot note bottom of page 489. **See also page 834. ‡This applies to starting engine by hand. Now that starting motors are used, the spark lever can be advanced slightly.

How To Change Gears.

Changing from Low Speed to Second Speed.

Fig. 2—Assuming the car started and running on first speed, before making the change to second speed fig. 2, it will be necessary to have the car traveling at such a rate—that the drop in speed during the length of time it takes to bring the gearshift lever from the first speed position, through the neutral gate and into the second—will not result in the car traveling so slowly that there will be difficulty in the engine picking up the load. It will not be necessary to attain a speed of more than 7 miles an hour to make this change on level ground. When a speed approximating this has been attained, make the change by a smooth **but quick** pull on the lever. You should practice the movement to such an extent, that the transverse movement in going through the neutral gate movement, will be made so quickly that it will hardly be apparent and will not interrupt—to a perceptible degree—the smooth movement of the gear-shift. In making the change to a higher speed, it is necessary that the throttle be opened as soon as the gears are meshed. The spark is also at once advanced slightly.

Changing from Low Speed to Second Speed —on a grade.

When the car is facing upwards, it is a little more difficult to be able to judge when the speed is sufficiently great to justify a change from first to second speed. The hill may be of such slope that it is an easy matter for the car to take it on high in ordinary running, but is still steep enough that the pause in the gearshifting act, is sufficient to cause the speed to drop considerably. In a case of this kind the driver should be able to judge just at what speed he should throw out his clutch and make the change. The steeper the hill the greater will be the speed required before the change can be safely made.

Fig. 3—In going from second to high speed the same directions apply, except that the complication of passing through the neutral gate is not present, and therefore the change is simplified to a slight extent.

In Changing from a Higher to a Lower Speed —high to first.

Fig. 9—In dropping from a higher to a lower speed a different set of circumstances will arise and a different method will have to be pursued.

When traveling through traffic it is sometimes desirable to change to a lower gear on level ground without slowing down the car. To attempt this by de-clutching and putting the lever directly into the lower speed notch—in the same way that this is done while ascending a hill—would be to invite a very noisy clash of the gears.

Instead: the change is made in three progressive steps, as shown in fig. 6 and fig. 1, and the speed of the car is not reduced to any appreciable degree.

The first movement shown at A in the illustration below is to disengage the clutch and carry lever forward from high to neutral. This leaves the car coasting with the engine running.

The clutch is now let in and the levers are in the position shown at B. Now this is the part where the skill is required and where practice is necessary.

—see further instructions under fig. 11 and illustrations below.

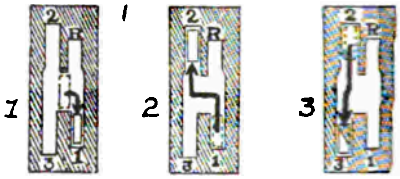
The engine is speeded up until **it is turning** at the same rate of speed as it **would be with** low speed engaged. It will take a **little practice** to accustom the ear to judge by the **sound of the engine** whether it is turning over at the **correct speed** or not.

After the engine is speeded up to the proper degree, the clutch pedal is depressed, **and the change** gear lever brought into low speed **as at** (C). **The same method will apply in going from second to first.**

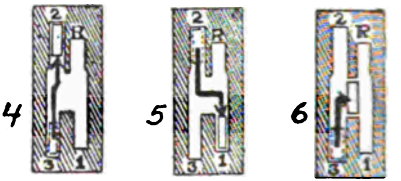
Trouble in dropping to lower speed on a hill can be averted, if the critical moment at **which to make** the change is learned. **If the driver waits too long** he may "kill the engine" and sometimes *place him*self in a very serious position.

If he tries to make the change too soon he will clash gears.

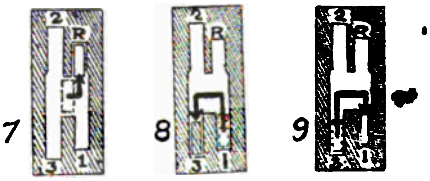
By changing at the critical moment however an easy, quick change can be made.



Neutral to Low Low to Second Second to High



High to Second Second to Low High to Neutral



Neutral to Reverse Low to High. High to Low

Above illustrations explain the movement of shift lever to obtain different changes of gear. For instance, Fig. 1 shows the change from neutral position to first or low speed; Fig. 2, shows change from 1st to 2nd, and Fig. 3, shows change from 2nd to 3rd.

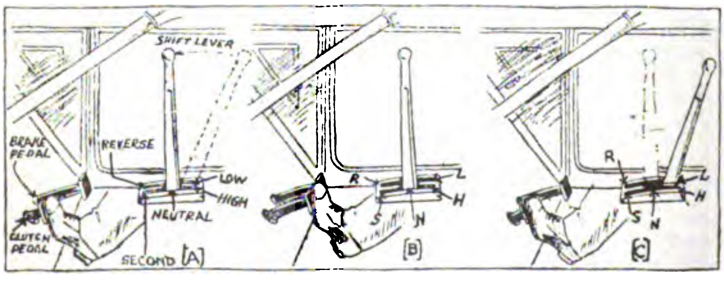


Fig. 11—Changing from "high" to "low."

A—clutch out and lever brought to neutral. B—clutch engaged with gears in neutral and engine speed regulated to correspond to speed of car on low gear; C—clutch held out with foot—gear shift lever is then moved back to low gear position and gear change is completed.

CHART NO. 211—Pointers on Changing Gears; movement of lever.

The above gear shift was used on early model Overland cars. The later Overland, Willys and Willys-Knight cars and in fact a majority of the three speed cars use gear shift as per fig. 1, page 490.

ith the operation of the foot throttle or ccelerator. The pedal is usually located etween the two large pedals on the foot oards and by pressing down, the engine may e speeded up, but when released it will pring back, slowing down the engine to the peed allowed by the position of the hand hrottle on the dash. Note how quickly he engine responds to the pressure of the foot. The success you will have in making gear changes, will largely depend upon the sensitiveness of your foot pressure. (See fig. 4, page 154, for explanation of an accelerator—see also chart 213).

Starting car and changing gears—see chart 210 and 211.

†To Stop Car.

Remove foot from accelerator to slow down engine and disengage clutch by pushing left pedal forward. Then apply the brake by pushing forward on the right pedal. When the clutch is disengaged the engine power ceases to drive the rear wheels, but the car will continue to coast, due to its momentum. The foot brake is used to overcome this momentum and should never be applied against the power of the engine, i. e., when the clutch is engaged. Do not slam down on the brake pedal and lock the rear wheels, for this not only shows lack of good judgment but is extremely hard on tires and may cause disastrous skidding. Anticipate the stop to be made far enough in advance, to enable you to bring the car to a gradual stop.

Before letting back on the clutch pedal move gear shift lever into neutral position. If you fail to do this the car will start ahead when the foot is removed from pedal and the engine is very apt to stop running, i. e., "kill the engine."

Emergency stop: Push both pedals forward and at the same time pull back as hard as possible on the hand or emergency brake lever. Do not get excited and pull back the gear shift lever. Remember, the brake is the longer lever furthest from you. (See fig. 1, chart 210).

If the road surface is wet and slippery a greater braking effect may be had by pushing in on the foot brake pedal intermittently, i. e., hold the brake pedal down for an instant only, then release and apply again. Keep doing this until the car is brought to a stop. If the brake is constantly applied the rear wheels will be locked and traction will be lost.

To Stop the Engine.

Turn switch key to "off" position. At the same time press the accelerator pedal, thus opening the throttle after the spark has been cut off and allowing the engine to draw in a rich mixture while coming to a stop. The gas drawn in will remain unexploded in the cylinders and greatly facilitate future starting. See page 321.

Be sure the clutch is thrown "out" or gear shift lever in "neutral" position when stopping engine.

To stop the engine in cold weather so that it can be restarted easily, shut off air to carburetor by moving the air regulating handle in a right-handed direction to starting position. If this in itself does not stop it, then push in the switch key to short circuit the magneto.

When leaving the car, always remove the key from the switch, so the engine cannot be started without your knowledge.

**Running a New Car.

***In setting up and starting any new piece of complicated machinery, you would expect to watch it pretty closely and go a little easy until its various bearings, parts, etc., had become thoroughly "worked in."** An automobile is no exception to the rule. While every bolt and nut in the automobile is drawn tight, and secured with either cotter pins or lock washers when the car leaves the factory, nevertheless it is advisable to go over a few of the more important points and make sure that everything is in perfect shape. (see pages 203 and 651, "running in" a new engine.)

The folowing points should receive your special attention, during the time the car is being driven the first few hundred miles: Between the upper crank case and the oil pan, there is usually a gasket, see page 62 and 64. During the first few days of service the gasket may become slightly compressed, thus loosening the crank case to oil pan bolts, consequently go over the nuts on the bottom of the oil pan with a wrench and tighten them up. Drive a few days and try them again. Continue to do this until the gasket has become fully compressed and the parts have settled into permanent working position. If you will take this precaution the joint will be absolutely tight and you will never have any trouble, such as, loss of oil or water and dirt being washed into the oil pan and then circulated with the oil through the bearings, causing excessive wear and cutting.

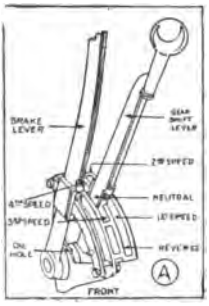
At first, occasionally go over all of the **bolts** (illustration E, page 64), **that hold the engine to the frame,** and see that they are kept tight. If you find them perfectly tight after inspecting them two or three times, you

---

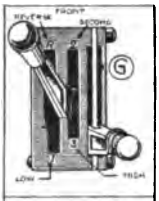
***Starting engine by opening switch** is unusual but it is obvious that the idea of flooding the carburetor is to obtain a temporary enriched mixture, but the value of the flooding is lost if it be done when the cylinder and induction pipe are full of mixture, any gasoline vapor left in this overnight having long since evaporated.

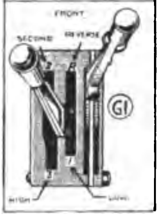
If the engine be turned over a few times with the switch off, the air is expelled, and a thin mixture of air and gasoline inhaled in its place. Flooding then gives a temporarily rich mixture in the cylinders and the engine will start at the first trial with switch on. **Also see page 153.**

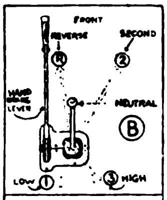
†See also page 495. **See pages 203 and 651.

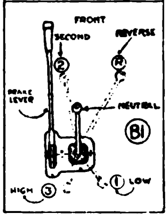


A four speed gate type gear shift; Pierce-Arrow. See page 500, fig. 22, for Locomobile.









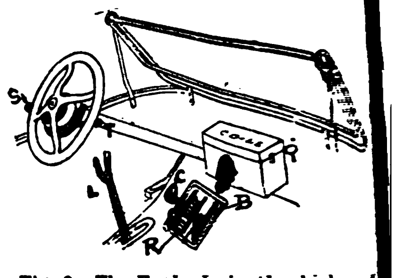


Fig. 9—The Ford—L, is the high speed and brake lever; C—clutch pedal; R—reverse; B—brake pedal; S—spark lever; T—throttle lever.

Gear Shift Movements.

The three gear shift principles in general use are shown in the above illustrations. The one other type, fig. 9, is the Ford, which is also explained under the Ford instruction.

Three speed gate type: The gate selector is plainly shown in G and G1. The gear shift lever is shown in neutral position. By moving this lever to the side, then forward or backwards the different gear shifts are obtained. Note in G, the first or low speed is obtained by moving the lever back, on the left side, whereas in G1, first speed is obtained by moving lever backwards to the right. G is the S. A. E. Standard fig. 1, below, and is used most.

The ball and socket type gear shift: Is shown in B and B1. This principle is also explained on page 49. The lever in this principle shifts the gears in precisely the same manner as in the gate type selector, but instead of a gate, the ball and socket is used to obtain the various movements.

When in center position, lever is in "neutral." Note in B, to obtain first or low speed, lever is shifted backwards, to the left, whereas in B1, it is shifted backwards to the right. The ball and socket type, is the one most cars are equipped with at the present time and B, corresponds with the S. A. E. Standard fig. 1 below and is used most.

Four speed gate type selector: The Pierce-Arrow gear shift is illustrated in A. This principle corresponds with S. A. E. Standard, fig. 2 below, see also page 500, fig. 22 for Locomobile four speed gear shift.

**S. A. E. Standard Gear Shift Movements.

The gear shifts as recommended by the Society of Automotive Engineers are illustrated as follows:

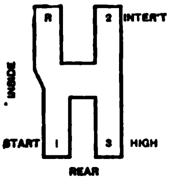


Fig. 1—3 speed.

Fig. 1 — Three speed movement; R—is reverse; 2—intermediate or second speed; 1 — low or first speed; 3—third or high speed. Note reverse and second speed are forward movements.

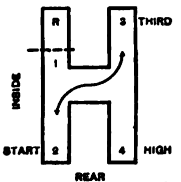


Fig. 2—4 speed.

Fig. 2—Four speed movement: This corresponds with Pierce-Arrow above (A) and Loco, fig. 22, page 500. Note the reverse is a further movement in slot with 1st speed movement.

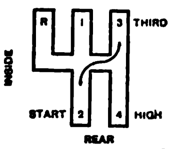


Fig. 3—4 speed.

Note difference is in reverse.

Fig. 3—Four speed; same as fig. 2, except the reverse (R) is in a separate slot; to the side of the 1st speed (1).

Four-speed transmissions for motor trucks shall have gear-shifts so arranged that the lever-handle positions for forward speeds are as shown in figs. 2 and 3. The high-gear (or 4th speed) position corresponds with that for three-speed transmissions (3—fig. 1), and low-gear (or 1st speed) position corresponds with reverse (R) for the three-speed transmission.

The location of reverse position is left optional, it may be as arranged in figs. 2 or 3, or could be in a separate slot as per fig. 3, but in rear instead of front —which is the method as used on the Garford truck and many others, but there must be protection by a latch or equivalent against accidental engagement of reverse.

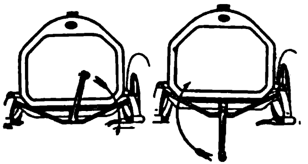


Fig. 12.

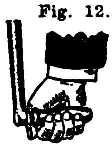


FIG.13 How to Hold the Crank. Proper method to grasp handle of starting crank. If started by hand, otherwise see electric starting instruction

*How To Use A Starting Crank.

Fig. 12 — Always pull up on a starting crank — never push down. With the crank hanging straight down, push it in as far as possible and turn in a right-handed or clockwise direction until it catches. Now pull crank over against the compression as quickly as possible by giving it a quarter or half-turn in the right hand direction. The engine should start. If it does not start after doing this three or four times, do not tire yourself out by continually cranking. Something is in need of attention. Analyze the cause of trouble in the manner outlined in "digest of troubles" Instruction 43, and remedy accordingly.

CHART NO. 212—Gear Shift Movements Explaining the Difference between the Gate and Ball and Socket Type—see also pages 49, 496, 497 and 543 to 546. S. A. E. Standard Gear Shift Movements.

***The starting crank is now seldom used but occasionally it is necessary, therefore instructions are given as a matter of information. **The gear shift of the A and B Army Truck is as per fig. 3 and 1.**

need never fear that they will loosen up.

It is advisable to put a wrench to all nuts on different parts of the car and make sure that they are perfectly tight after it has been driven a hundred miles or so. When they have once been screwed up as tightly as possible and the car has been thoroughly "run in," there will not be so much danger of loosening up and causing damage.

Spring clips fig. 8 (upper illustration), page 26, **will loosen** if the nuts on the clips are not tightened ocasionally. It is **very** important to tighten these nuts often. **Fender bolts** also demand attention. **The universal joints** should be kept well supplied with grease, see bottom of page 43.

Lubrication of a new car. It is needless to remark that lubrication is one of the most important things to look after on a new car. All parts should be thoroughly lubricated and greased as directions provide on page 196, and follow along the lines as there suggested. In the absence of directions from the maker study the lubrication subject carefully. Remember one thing—cheap oil will cost ten times more—maybe a hundred times more in the long run, in the way of repairs. The best oil is none too good.

Draining oil from engine: When the engine is assembled every part is cleaned as thoroughly as possible but in the early stages of service, small metallic particles may be shaken or worn off the engine parts, falling into the oil reservoir. Consequently after the car has been driven about two hundred miles drain out all of the old oil as per directions. See also page 201.

After having drained the crank case and transmission case, rinse out with kerosene, replace screw plug in the oil reservoir and pour the kerosene through the breather pipe, if so equipped using a gallon or more. With switch plug **removed,** push in on the starter pedal so that the engine turns over rapidly for ten or fifteen seconds. By running the engine with the starter for a very short interval the kerosene will be forced through the entire oiling system, flushing it out and then running out the lower drain plug hole, which should be left open. Drain out the kerosene very thoroughly, and then replace all plugs and refill the oil reservoir. The transmission will be refilled by the fly wheel as soon as the engine starts (if it is a unit type). The oil will then lower and no doubt more oil will be necessary. If you wish to derive the best results from the oiling system, this operation should be repeated after the car has been driven another five hundred miles or thereabouts. After this the oiling system needs to be rinsed out only once every thousand miles and it will require no other attention since now the oil is bound to be clean and it is positively circulated to every moving part with little chance of failure.

Hill Climbing.

Until you have become thoroughly familiar with the operation of the car, and have mastered the things necessary to make a good driver, do not attempt to climb every hill you see" on high," because your neighbor possibly has said that his car would do it. There can be nothing more detrimental to the engine and driving parts than to try climbing every thing on "high." The first and second speed gears are placed in the car for a purpose, and if the hill that you are approaching is at all steep, shift into "**second**" a little before you are really on the hill. Do not try to go into "**second,**" however, at any time unless the speed of your car has been reduced to the pace at which the second speed would carry you if it had already been changed. Many accidents, and serious ones, have resulted from a driver attempting to rush a hill "on high," getting half way up and having the speed of the engine so reduced that when he came to shift into low it was too late; the engine would not accelerate sufficiently to carry the car up on low, and possibly the brakes were not working just as they should, the result being that the car would back down the hill faster and faster, until it finally landed in the ditch. Backing down hill with brakes is a task for a skillful and experienced driver and even he cannot guarantee a good job. It is a most confusing situation and requires instant good judgment.

The secret of successful hill climbing is to at all times keep your engine running a little faster than its work requires it to run, i. e., keep it "ahead" of its work so that it is ready for extra duty without stalling at the critical moment. The foregoing does not mean that it is impossible to climb many hills "on high," but it is best not to try until you are **sure** of yourself and of your ability to get into **second,** or even **first** if necessary, halfway up the hill, and also to determine from the sound of the engine whether it is "working hard." If you must go into a lower gear on a hill, shift with a quick, firm movement and take care not to let the momentum of your car be reduced any more than is absolutely necessary. Every second that you have the clutch disengaged on a hill for gear shifting, counts, as the car slows down at a very surprising rate.

If in climbing a hill on "third," the engine has been stalled before reaching the top, it may require considerable skill to start from your standing position on the incline. Immediately upon finding yourself in such a predicament, apply the emergency brake with all your strength and be sure that the brake ratchet catches, then throw the gear shifting lever into neutral. After starting the engine again, push out the clutch (leave the hand brake still on), push the gear lever into first speed and slightly race the engine (the only time it is permissible, excepting when in a mud hole or the like)—take hold of the hand brake and keep the engine speeded until the brake has been entirely released, the clutch entirely engaged, and a safe start has once more been made up the hill. Experience is the best possible teacher where there is a considerable amount of hill work to do.

Learn to drive your car by ear. Learn what the different little sounds that vary under different running conditions mean. If the speed of your engine has been so reduced by running through a heavy stretch of sand, that you can almost count the explosions and at each impulse you feel the whole car jar, you can rest assured it is high time you went into a lower gear and let your engine do the hard work a little more advantageously. No matter what the power of your car; hills, sand and hard work have to be met very much the same way. **Remember,** keep the engine ahead of its work and at the same time do not "race" it unnecessarily.

***In descending a long hill it is possible, even advisable to use the engine as a brake,** and if the hill is not too steep, the descent can be made without resorting to the use of the rear wheel brakes. To accomplish this, shift into first or low gear, close the throttle and leaving the gears and clutch engaged, open the ignition switch to stop the engine from firing. As the car coasts the rear wheels will be forced to turn the engine over against compresson in the cylinders, hence the braking effect. By opening the throttle the resistance is still further increased. The maximum of resistance and the best control on a dangerously steep hill may be obtained by shifting into first, switching off of the ignition, and applying the brakes at intervals. Just before reaching the bottom of the hill, with the car still moving at a fair pace, close the ignition switch and the engine will start firing again.

On a long descent, when you find it necessary to use the brakes, apply the hand and foot brakes alternately, to avoid burning out the brake linings.

Points to Remember in Operating a Car.

Starting by hand: This sounds ancient, but no doubt there are many of the older models of cars with hand starters still in use, therefore as a matter of "information" we will devote a few lines to the subject.

Grasp the starting handle as shown in fig. 13, chart 212; that is with the thumb on the same side of the handle as the palm. Never bear down on the crank. You may do it safely many times, but you incur the risk of a kickback; so don't do it.

Cranking is not an art, but simply a "knack." You will realize this better after you have seen some one physically much weaker than yourself start an engine that you seemed totally unable to throw over by main force. Get the fly wheel to rocking to and fro, until with a last, powerful acceleration the piston is carried over its compression by the momentum of the fly wheel as well as by the pull of your arm. A new engine always turns over somewhat stiffly, because all bearings are closely fitted, to insure long life. After a little while, it will "loosen up."

If it does not start on the first upward pull, because the cylinder walls are still cool, or because the first and incomplete suction stroke has not brought sufficient gas from the carburetor into the cylinders, repeat the operation once or twice and the engine will start at a lively pace; otherwise see "Digest of Troubles."

Control of the speed of engine: (See page 67 and chart 213.) The throttle lever connects to the throttle on the carburetor. By opening the throttle lever, more gas is permitted to enter the cylinder and consequently more speed.

To increase the speed of an engine, the usual procedure is to open throttle and as the throttle is advanced, gradually advance the spark.

To decrease speed, retard spark and throttle. When the spark lever is moved, on the steering wheel, it in turn moves the timing device, or commutator, or contact breaker; either advancing it so that it will make contact **early**, or retarding it so that it will make contact **late**. It is possible to often times govern the speed of an automobile when a small amount of gas is being used, by advancing or retarding the spark. In "advancing," the speed is increased and in "retarding," the speed is decreased.

The Accelerator.

There is another pedal which also performs some of the functions which so far have been taken care of by the hand throttle lever, and this other pedal is the so-called "foot throttle or accelerator." It is located in the neighborhood of the right foot. Pressing it down opens the throttle and a spring tends to close it as soon as the pressure against it is discontinued, as illustrated on page 154, and fig. 23, page 497.

The hand throttle lever and the accelerator are inter-connected. See fig. 4, page 154. Advancing or retarding the hand throttle lever will move the accelerator down or up. But pressing the accelerator will not actuate the hand throttle lever. It is therefore possible to set the hand throttle lever for any desired minimum speed and to this minimum speed the foot throttle, or accelerator will conform. For instance, should you first set the hand throttle so that the car would proceed at the rate of, say, twenty miles an hour, and then use only the accelerator, the latter will not close the throttle below the mark for which the hand throttle is set.

In operating the car it is possible to use either. Using the accelerator gives greater freedom to the operator's hands. The hand throttle lever is used in starting, and in touring as an occasional relief, to rest the foot at times when the car is run considerable distances without material changes in its speed (see chart 213).

---

*In other words the car will run the engine, and owing to the fact that you are in low the gear ratio is such that the car has the long end of the lever, to get an idea of what this means; jack up the hind end of your car sometime and put it in low; then try to turn the rear wheels.

*Importance of the Clutch.

The clutch of an automobile is a device by means of which the power of the engine and the driving mechanism may be connected or disconnected at the will of the driver. This particular part is probably used more than any other part of the car, and a careful study of its purpose and principle is advised. Though the device is simple and its use plain at first glance, the clutch, nevertheless, lends itself to a number of skillful uses in the hands of the experienced driver. **Remember to always "throw out" clutch before changing gears,** see chart 210, and pages 37 to 44.

When the clutch is "let in," or engaged, this should at all times be done smoothly and so gradually that the motion of the engine shaft is transmitted to the drive shaft without jarring.

A suddenly let-in clutch will do one of two things; either rack the mechanism of the entire car, or stall the engine. With a little practice the left foot may be schooled to let the clutch in quickly, yet gently and smoothly.

When you meet a stretch of road covered with sharp, broken stones, it is an excellent plan to speed your car a little before you reach the stones and then disengage your clutch, permitting your car to coast over the bad spot. By shutting off the driving power you protect your tires against a very destructive action, termed the "traction" which otherwise would be set up between the sharp stones and the tires.

When reversing, remember to bring the rear wheels to a dead stop before letting the clutch in. Complete familiarity with the motions of going from one speed to another and back again should also be acquired before attempting to run on the open road, see pages 51 and 488.

When the control of the engine and change speed gear is well understood, the first run on the road may be made, but first study the rules of the road (page 502).

Instructions on Steering a Car.

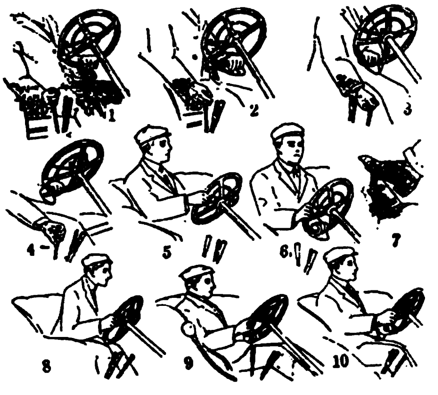


Fig. 4.—Correct and incorrect positions in driving: 1—Fierce grip, a bad method; 2—Correct hold for forward movement; 3—Finish of forward movement; 4—Alternative grip suitable for many gears; 5—Awkward hold of wheel; 6—Proper and comfortable hold; 7—Wrong foot position; 8—Nervous, uncomfortable position; 9—Careless, lounging position; 10—Correct "seat." (Popular Mechanics.)

The positions to assume in steering or driving a car are shown in fig. 4. A very slight movement of the steering wheel or lever is sufficient to turn the car, and too sudden a turn may cause an upset.

Select a straight road, as wide as possible, and with the engine running slowly, throw in the low speed. The car will move forward slowly, and it will then be necessary to steer. The first inclination will be to grip the wheel as tightly as possible, but after a little running a light grip will be found sufficient. At this stage it is necessary to learn **self-control first** and not to get rattled.

If the car begins to run off the road, or into an obstruction, throw out the clutch and apply the foot brake so that it comes to a standstill. When the excitement has died down, try again, and it will not be long before steering comes easily.

There is no time lost between the turning of the steering wheel and the turning of the car; when taking a corner do not move the wheel until the car is at the point where turning is necessary.

†Pointers on Changing Gears.

When taking your position in the car, place the speed gear lever in the "neutral" position, release the brakes, "throw out" the clutch. Practice pressing the clutch pedal and releasing it, until the feel of it is understood, (see fig. 1, chart 210).

The clutch pedal should be depressed sharply, and released slowly, which throws out the clutch quickly, and throws it in slowly. Do this a number of times, until it becomes natural and well understood.

Speed up the engine slightly, throw the clutch out, and move the control lever forward to the notch that indicates the slow or first speed.

Always let the clutch in slowly. The clutch must be permitted to take hold gradually—let it slip a little at first, to pick up more and more of the load, so that finally it turns the wheels steadily. When the clutch has taken firm hold, throw it out, and move the control lever back to the neutral position.

These motions should be gone through a number of times, until familiarity with it makes the gears and clutch go in and out of engagement smoothly.

Get the wheels going on low speed, and then move the control lever to the intermediate or second speed. Always throw clutch out with foot pedal before changing speeds.

---

†By referring back to instruction No. 6, on pages 48 and 51, additional pointers and information can be obtained; see also page 488. See also, foot note page 662.

*Learn to drive by throttling the engine instead of constantly throwing clutch out. The average driver uses the clutch about twice as much as he should.

When the change from low to second speed is well understood, and can be performed smoothly, move from second to high, increasing the speed of the engine sufficiently, and being sure to first throw out the clutch. [*]If the gears do not go into mesh easily, but grind and growl, try it over again, coming back to low speed first. Never try to force them, but make the change quickly.

When running fast, never suddenly make a change from high to a lower speed. This change must be made when car has slowed down and it is evident that the engine will not pull the grade on the high speed. The gears, however, can be changed from first to second and second to high when engine is running moderately fast.

The usual plan is to start the car off on low speed, then after car is in motion, change to second, and when car is well under way, then to high speed.

The low speed and second speed are used principally for starting a car off and for climbing hills most of the running being on high speed.

When running on low and second speed, the engine speed should be as low as possible, to keep it from overheating.

A car is usually run on high speed, because then the engine is running slowly in relation to the speed of the car.

The best driver gets the greatest distance with the fewest revolutions of the engine, which means less wear, and less fuel and oil.

The lower speeds are principally necessary for hill climbing, for which the engine must have more pull or better leverage on the wheels to take the car up.

As the car ascends the hill, the engine will begin to slow down as it feels the load. Retard the spark gradually, giving more gas to keep engine working smoothly, but when it slows down and shows signs of distress, it is time to change to second speed.

Coasting.

Coasting mountain roads. Whenever you approach a long and steep grade, it is best to shut the throttle, switch off the ignition, put your gear speed lever into first speed and allow the car to run the engine.[†]

This is better than using the brakes. As it gives you absolute control of the car at all times.

If the grade is long and steep, use the foot and emergency brakes alternately. This equalizes the wear on them.

While the speed of the car in going down hill may be kept under control by the brakes; the engine can also be used as a brake. The engine is then being driven by the forward movement of the car. The effect is to convert it into an air compressor, and the resistance it will present will keep the car in check on all but the steepest hills.

This will also have a cooling effect on the engine and save the brakes, which on a long hill are liable to be burned and ruined.

The switch should be turned on again, however, before the bottom of the hill is reached so that the engine will start to run again under its own power.

How to use the Brakes.

When the brakes are suddenly applied with full force to the wheels of a car speeding along at the rate of say, thirty miles an hour, the braking action will be so powerful as to stop immediately the rotation of the driving wheels—but the car will not come to an immediate standstill; its momentum will send it forward and the locked rear wheels will slide over the ground with most destructive effect on the tires.

When you consider that in railroad practice the so-called "flat wheel" is produced by too sudden braking, you will be able to appreciate the effect which a similar practice must have on the soft rubber tires of an automobile.

Bear in mind, therefore, that the best method of using the brakes is that which applies pressure on them so gradually that the forward movement of the car and the rotation of the wheels come to a stop **together**. See pages 492, 28 and 29.

Nothing is more severe on a car than the spectacular stopping often indulged in, by ignorant drivers, in an effort to "show off"

The careful driver shuts his power off before he reaches the stopping point and permits the car to carry him along on its momentum, bringing it with a gradual application of the brakes, to a halt at the exact spot.

Although the foot or service brake may be used to slow the car down while the clutch is in engagement, it is poor practice to do so and would burn the brake lining.

Whenever it becomes necessary to slow down, release the clutch first; that alone will have an immediate slowing-down effect on the movement of the car, because it disconnects the power. If additional checking is needed, apply the foot-brake or, for a quick stop, the foot and emergency brakes together. To make it plain the **clutch pedal goes down first, the brake pedal next.**

If a full stop is not desired, **merely a** temporary slackening of the **speed, release** the brake pedal first, then let **clutch pedal** come up. If you did the reverse, the engine would be compelled to pull against the brake, with consequent rapid wearing down of the brake lining. (See also "brake adjustments," in the repair subject.)

---

[*] See charts 211 and 212 and study the change of gears and operation of the selector lever.

[†] Note: This plan is used only in an emergency. The pistons have a tendency to draw gasoline into cylinders which works down into crank case and thins the lubricating oil.

No motorist is qualified to give his car the best care until he has mastered the control of the gears and of the brakes.

Slipping brakes are usually caused by oil working out the rear axle onto brake lining.

If the Brakes Fail.

If the engine stops while descending a hill, the brakes should be thrown on at once to keep the car under control. If poor adjustment of the brakes renders them insufficient for this, then place gears in low speed, this will tend to check the car. It is then a matter of steering the car to best advantage. **If ascending a hill and engine stops and brakes fail**, try putting gears in reverse. This will then turn the engine in right direction and ought to start it. It may be possible to steer it—owing to its extremely slow speed—off the road into a bank or other obstruction that will stop the car without much damage to it or its occupants.

Situations such as this require a cool head and steady hand, and the more experience in operating the driver has, the greater are the chances for handling it in the right way.

*Stopping a Car.

Stopping a car on an up grade and starting again requires skill, for the brakes must be withdrawn and the clutch let in at the same instant with one movement.

Until this skill comes through experience, the best thing to do when this is necessary is to block the wheels with stones or pieces of wood.

The beginners' idea of stopping is to throw off the power and put on the brakes. While this will of course, produce the desired effect, it is not correct, for it would rack the car and damage the tires. The car is heavy, and when moving tends to keep on moving, so that its stops must be gradual.

To stop, first retard the spark and throttle, to keep the engine from racing when relieved of the load. Make up your mind just where the car is to stop, and throw out the clutch a sufficient distance ahead, for the car to come to a stand of its own accord.

Brakes should be applied suddenly only when it is absolutely necessary, for they are powerful enough to lock the wheels and make the car slide. Sliding grinds the tires and means their quick ruin. The flashy driver, who brings his car to a sudden stop, is piling up a big repair bill.

When the brakes are to be applied, pressure should be brought on them gently at first, being increased gradually so that the car slows down gently.

It is easy to learn to estimate the distance at which a car will come to a stop when the clutch is thrown out, so that the coasting of the car may be utilized in slowing and stopping it.

When stopping, get into the habit of retarding the spark and throttling the mixture. By opening throttle just before shutting down the engine (with clutch out) starting the next time will be easier, as you are filling cylinders with gas.

If only a short stop is to be made, the engine may be kept running at its slowest speed, called "idling," but if the stop is to be for some time, cut off the ignition.

For a quick emergency stop, bear down on your foot clutch and foot brake pedal, at the same time pull back on the emergency brake, chart 210, fig. 1. The foot brake pedal (called the running brake) will do for all ordinary purposes and the emergency is used only when a quick stop is desired.

**When the Car Skids.

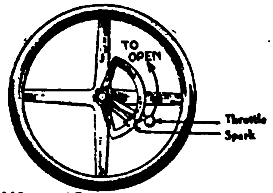
Although the driver feels helpless at first, a little experience will soon give him confidence. Most skids can be corrected by the manipulation of the steering and brakes. An expert driver can keep his car straight under almost any conditions, but it is impossible to explain just how he does it. Usually the rear end skids first, and in the right hand direction, this being caused by the crown of the road. Under such conditions, the skidding action will be aggravated if the brakes are applied, and the car may be ditched or continue to skid until it hits the curb.

The correct action in an emergency of this kind is let up on the accelerator pedal to shut off the power; but not entirely so, or it will have the same effect as putting on the brake. If the car seems to right itself, the power may be applied gradually and it will be advisable to steer for the center of the road again. However, if the car continues to skid sideways, steer for the center of the road, applying the power gently. This will aggravate the skid for the moment but will leave you with the front wheels in the center of the road and the car pointing at an angle. By so doing, you can mount to the crown of the road again and the momentum of the car will take the rear wheels out of the ditch on the right hand side. It is customary to advise turning the front wheels in the direction that the car is skidding, in order to correct the action, but this can hardly be said to be true in all cases, it holds good where there is unlimited side room, but usually the car hits the curb or is in the ditch, before you can straighten it out with the steering wheel.

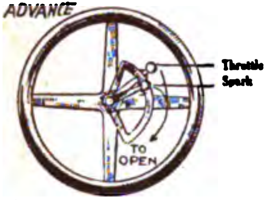
---

*See also page 489. **See page 551.

Spark and Throttle Lever Movements.



NO.1- UP-TO OPEN AND ADVANCE



NO.2-DOWN-TO OPEN AND ADVANCE

The spark and throttle lever used on most cars, move up to open throttle and advance the time of spark—as in fig. 1.

Some of the cars using the up movement are: Jeffery, Overland, Studebaker, Saxon, Paige, Regal, National, Pullman, Moon, Westcott, Oakland, Olds, Allen, Hupmobile, King, Mitchell, Chalmers and Hudson.

Some few cars use the down movement as in fig. 2: Haynes, Buick, Maxwell, Chevrolet, Ford.

Dodge, Marmon and Cadillac the levers are arranged differently, but principle is the same.

The Packard spark lever moves from the left, up, to advance, and the throttle from the right up, to open.

The Pierce spark and throttle lever movement is shown in fig. 10.

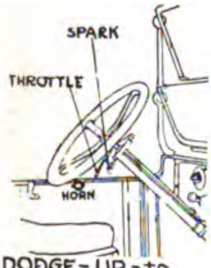
White spark lever moves down to advance. Throttle moves up to open.

Locomobile spark lever (54, page 500); when pulled as far back as it will go is fully retarded. When pushed forward, it is advanced. For driving between 15 to 45 miles advance the spark ¾ advance, below that speed retard to ½ advance. Above 45 miles, full advance. (see also page 497.)

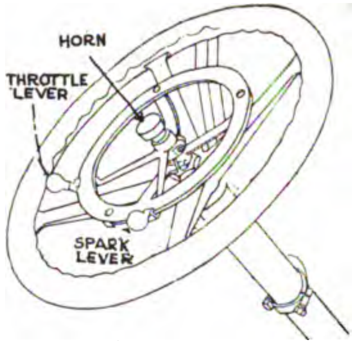
Franklin has but one lever (throttle) which moves up to open. The automatic advance of spark takes care of the spark advance. See page 242.

Where automatic spark advance is used, the spark lever is usually advanced ¾ of the way and the automatic advance takes care of further advance, at higher speed it is advanced full. Where automatic advance is used sometimes, there is no hand spark lever at all.

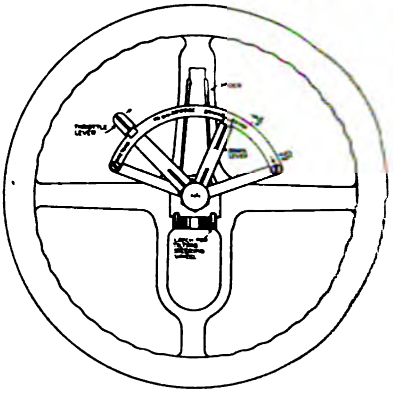
Accelerator: After engine is started, the throttle lever is opened just enough to keep engine from stalling and variation of speeds is made with the accelerator (see page 497, 154, 492). The spark advance is about 2/3 advanced.



DODGE-UP-to open & advance



MARMON-UP-to open & advance



Cadillac spark and throttle move from left to right to advance.

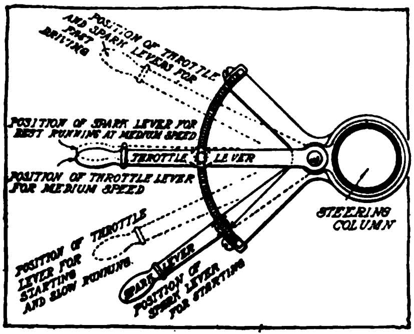
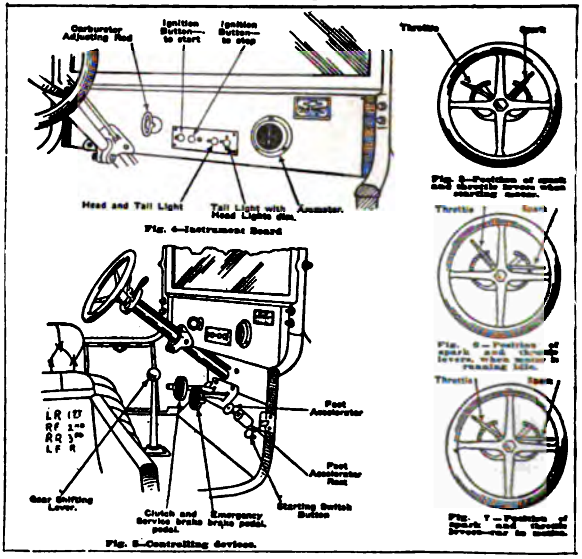

POSITION OF THROTTLE AND SPARK LEVERS FOR FAST DRIVING
POSITION OF SPARK LEVER FOR BEST RUNNING AT MEDIUM SPEED
THROTTLE LEVER
POSITION OF THROTTLE LEVER FOR MEDIUM SPEED
STEERING COLUMN
POSITION OF THROTTLE LEVER FOR STARTING AND SLOW RUNNING
SPARK LEVER
POSITION OF SPARK LEVER FOR STARTING

Fig. 10. Spark and throttle lever arrangement as used on the Pierce-Arrow, See page 500. Dotted lines show positions of spark and throttle levers in various running conditions.

Ignition timing; C4—set magneto fully retarded, piston 1" after top; battery ignition; set breaker box ⅛" from full retard and piston on top. B4—set magneto retarded, piston $\frac{3}{16}$" after top; battery ignition same as C4. A4—set magneto retarded, piston 1¾" after top; battery ignition ½" from full retard with piston ¼" after top. Firing order, 1, 5, 3, 6, 2, 4. (see page 849 for electric system).


Carburetor Adjusting Rod
Ignition Button—to start
Ignition Button—to stop
Head and Tail Light
Tail Light with Head Lights dim.
Ammeter.
Fig. 4—Instrument Board
Throttle
Spark
Fig. 5—Position of spark and throttle levers when starting motor.
Throttle
Spark
Fig. 6—Position of spark and throttle levers, when motor is running idle.
Throttle
Spark
Fig. 7—Position of spark and throttle levers—car in motion.
LR 1st
RF 2nd
RR 3rd
LF R
Foot Accelerator
Foot Accelerator Rest
Gear Shifting Lever.
Clutch and Service brake pedal.
Emergency brake pedal.
Starting Switch Button
Fig. 8—Controlling devices.

Chevrolet gear shift: LR—left rear; RF—right forward; RR—right rear; LF—left forward.

HART NO. 213—Spark and Throttle Levers. See page 542 for Gear Shift Movements of Lead- ıg Cars. See page 499 "Willys-Knight;"—this illustration gives the average position of levers different speeds.

g- 23—Locomo-
steering column
ing accelerator
connection. etc.

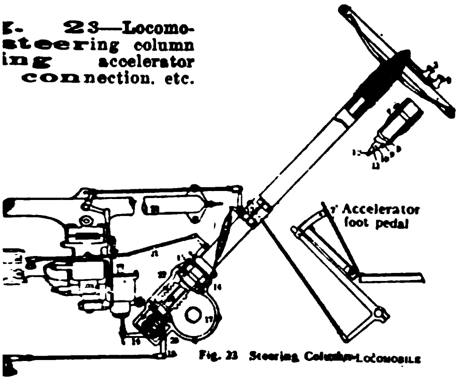
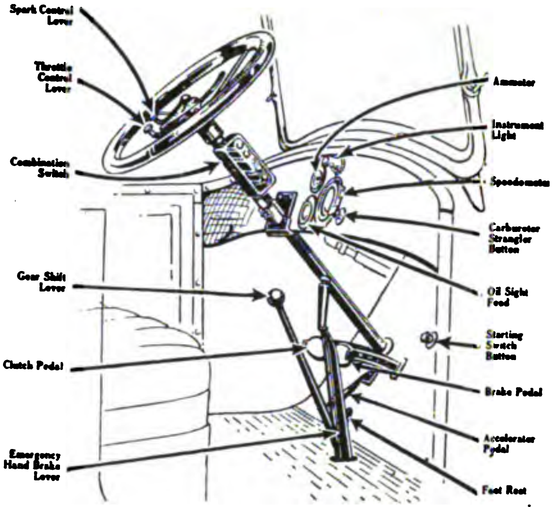


Fig. 23 Steering Column—Locomobile

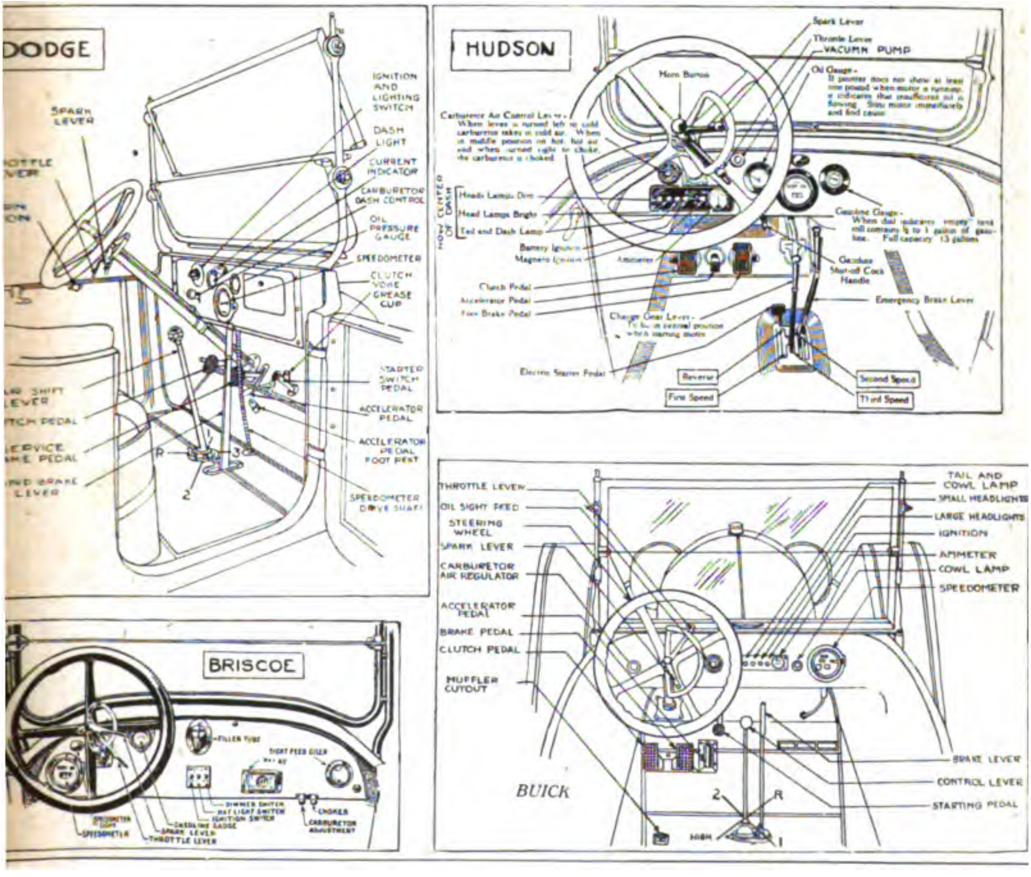
—Steering wheel
—Spark advance lever
—Hand throttle lever
—Air adjusting collar
—Accelerator pedal
—Outer casing
—Steering shaft
—Quadrant bracket tube
—Throttle tube
—Spark advance tube
—Steering column bracket
—Adjusting ring for roller bearings

15—Lock ring for No. 14.
16—Steering worm
17—Worm wheel
18—Spark advance mechanism
19—Hand throttle mechanism
20—Steering worm housing
21—Carburetor air adjusting rod
22—Grease plug worm gear housing
23—Inlet pipe to cylinders

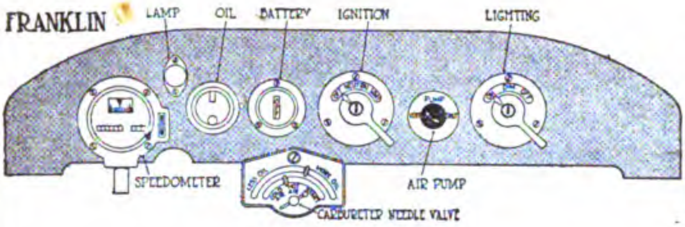


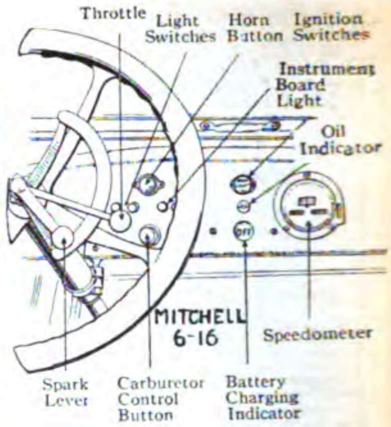
Overland dash and control units—It is practically the same on all Overland cars—except model 90 and Country Club models, which have "ball" gear shift, whereas others have the "gate" type per page 49, fig. 2. See page 49 for gear shift movement; page 358 for electric system. Also page 254 for thermostat of ignition system.

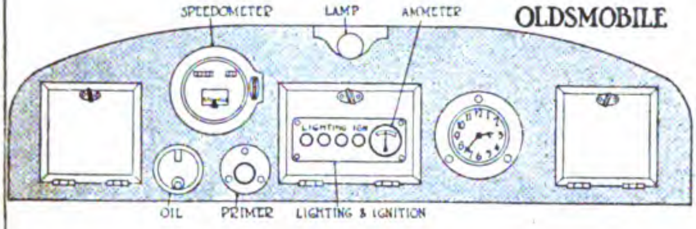
almers gear shift, is S. A. E. three speed ndard; fig. 1, page 490.

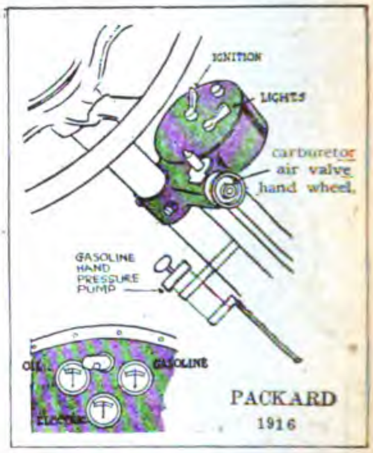


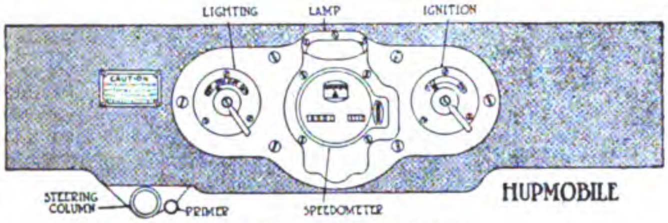
HART NO. 214—Gear Shift Movements and Instrument Arrangement on Dash of Some of th eading Cars, (see "Standard Adjustments of Leading Cars," page 542, for Gear Shift on other cars)

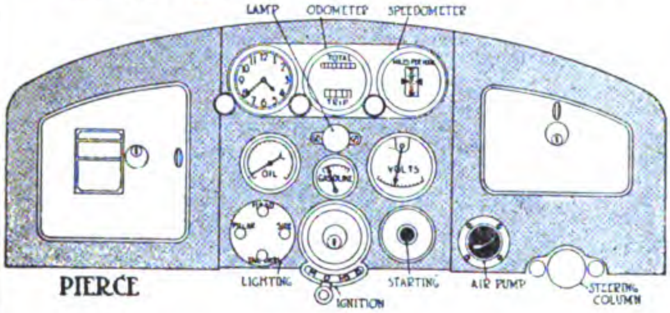


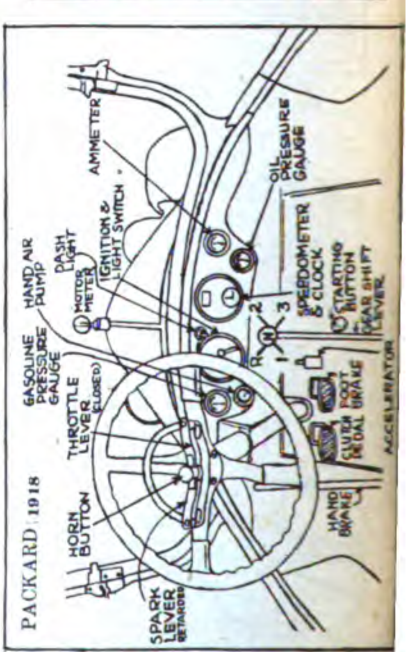




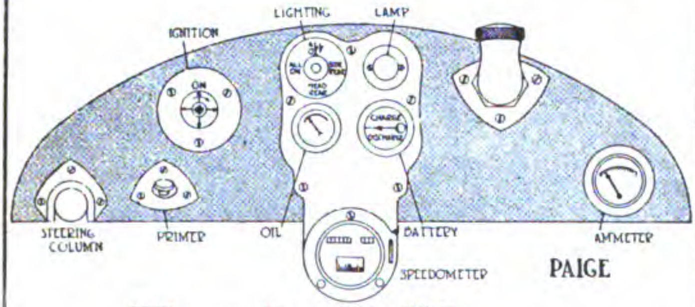








Packard "3-25 & 3-35" instrument boar and control, also showing change spee position.



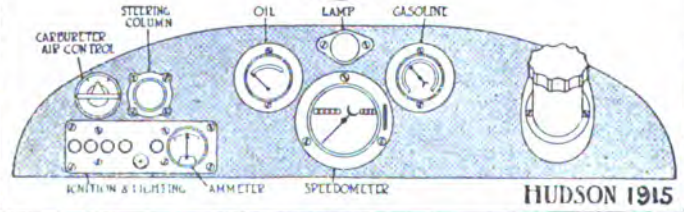
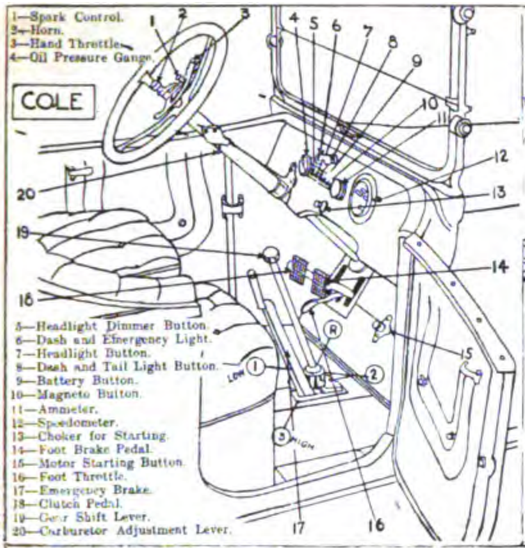
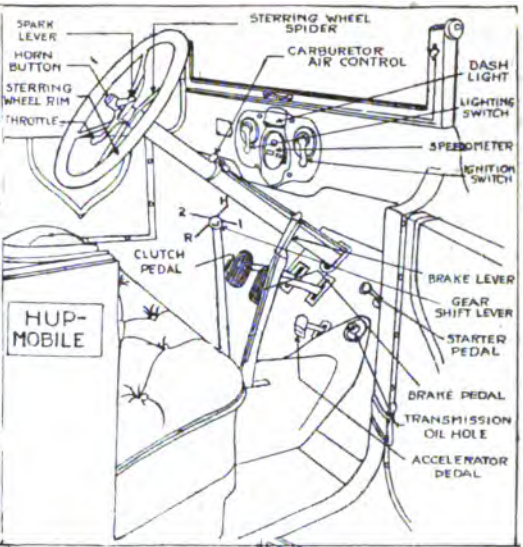
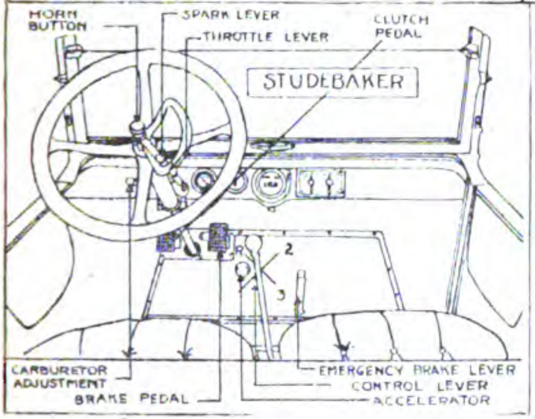
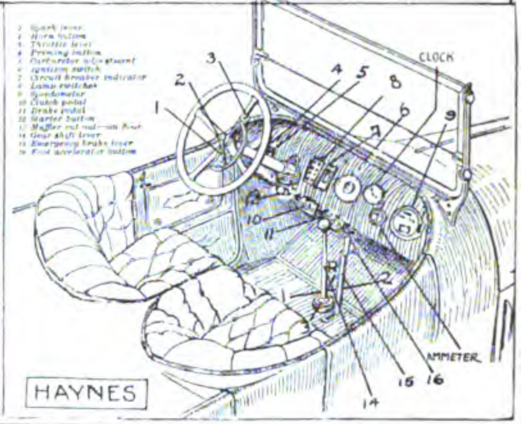


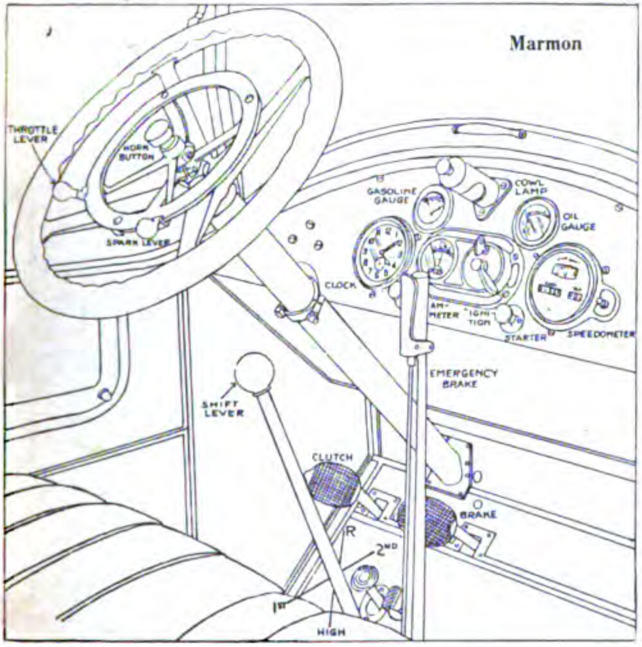
CHART NO. 215—Dash Board Instruments on Some of the 1915 to 1917 Leading Cars. See page 43 to 545 "Specifications of Leading Cars," for the Different Electric Systems, Carburetors, etc. on Leading 1918 Cars.



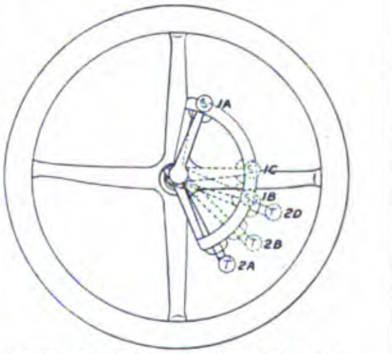








Willys-Knight 4 and 8, Willys 6, and Overland gear shift—see page 490, fig. 1. See pages 358 and 497 for switch connections which is practically same on all.



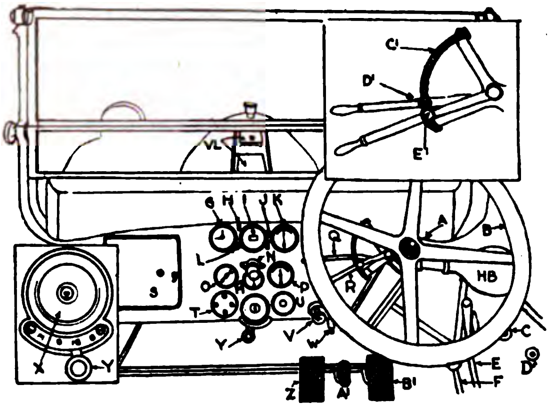
THE WILLYS-KNIGHT EIGHT

FIG. 4.—Spark and Throttle Control Lever

1A—Spark Control Lever fully advanced (for running position)
1B—Spark Control Lever in position for hand cranking
1C—Spark Control Lever in position for use of Electric Starter
2A—Throttle Control Lever closed (idling position)
2B—Throttle Control Lever in position for cranking
2D—Throttle Control Lever open

CHART NO. 216—Gear Shift and Instrument Arrangement of Leading Cars.

See page 133 for Cadillac; page 204 for Studebaker Chassis and page 368 for Studebaker Electric System. By referring to index for name of car, various gear shifts, etc. can be located.

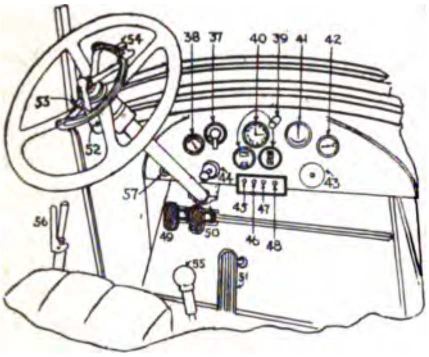


W—Plunger for priming.
X—Starting switch (lock above).
Y—Starting switch handle.
Z—Clutch pedal.
A-1-Accelerator pedal.
B-1-Brake pedal.

Pierce-Arrow Dash and Control Units

A—Gasoline regulator on column.
B—Steering wheel.
C—Dimmer button.
D—Klaxon horn button.
E—Hand brake lever.
F—Gear shifting lever. (see page 490)
G—Clock.
H—Handle to operate ventilator (VL) hood.
I —Autometer or Odometer.
J —Knob for setting tenths of a mile.
K—Speedometer.
L—Knob for setting odometer trip back to zero.
M—Gasoline gauge.
N—Dash lamp.
O—Oil gauge.
P—Ammeter.
Q—Spark lever. (see page 496).
R—Throttle lever.
S—Left hand dash cabinet door.
T—Lighting switch.
U—Starting button.
V—Hand pressure pump handle (pointing to the right,—"off" position; arrow pointing to the left—"on" position).

See page 349 for Pierce-Arrow electric system and page 496 for ignition timing and spark and throttle movement.



Locomobile Dash and Control Units.

37—Ignition switch.
38—Gasoline pressure gauge.
39—Dash light.
40—Speedometer and Clock.
41—Voltmeter.
42—Oil Gauge.
43—Locking switch
44—Hand pressure pump.
45—Starting button.
46—Panel light button.
47—Side and tail light button.
48—Head, tail light button.
49—Clutch pedal.
50—Brake Pedal
51—Accelerator pedal.
52—Carburetor adjustment.
53—Throttle lever.
54—Spark advance lever.
55—Gear shift lever.
56—Hand brake lever.
57—Dimming button.

See page 362 for Loco electric system; page 542 for firing order; page 108 valve timing; page 496 spark lever movement.

Fig. 21—Shows the Locomobile operating levers and fig. 22, the 4 speed "gate," showing the movements of reverse, 1st, 2nd, 3rd and 4th speed—see page 490.

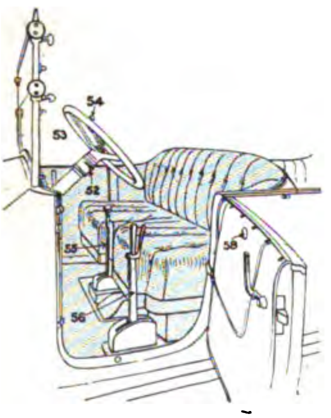


Fig. 21—Locomobile operating lever.

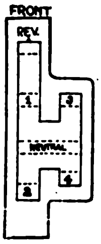


Fig. 22.

Chandler.

Fig. 23—Chandler Dash and Control units—the gear shift movement is the S. A. E. standard 3 speed gear shift shown on page 490—which is used by most of the manufacturers, see page 542 for firing order.

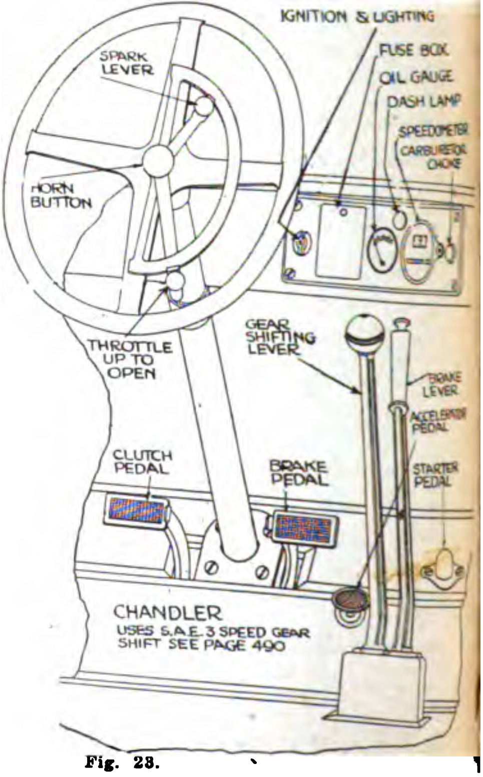


Fig. 23.

T NO. 217—Dash and Control Units of Pierce-Arrow, Locomobile and Chandler.

INSTRUCTION No. 35.

RULES OF THE ROAD: Rules for Driving, Passing and Turning. Traffic Regulations. Signals. Pointers on Driving.

The driver of a car should be careful to observe the rules of the road, for damages are not so liable to be collected, if he can prove that he was where he should have been.

Throughout the United States, the **invariable rule is to keep to the right;** in England it is just the opposite.

*Street, Traffic and Parking Ordinances.

The following is a fair example of traffic rules which may vary slightly, but practically represent the rules in different large cities.

The "one way traffic" and "congested district" will vary as to name, but no doubt in all large cities there are congested districts and one way traffic which should be enquired about when entering a city while touring.

Lights.

Lights are required on all vehicles, whether standing or moving, from one-half hour after sunset to one-half hour before sunrise during the months of October to March inclusive, and from one hour after sunset to one hour before sunrise during the months of April to September inclusive.

Automobiles: At least one light on each side of the front which will show white when viewed from the front, and one light on the rear which shall show red when viewed from the rear, all visible not less than 300 feet, with a white light shining on the license tag.

Horse-drawn vehicles: At least one light shall show white from the front and red from the rear, inobstructed a distance of at least 300 feet.

Lights and warnings upon extensions: Any vehicle so loaded that there projects to the rear any part of its load to a distance of more than five feet shall have an extra light so located as to be visible from both sides of said projection to the rear and to the utmost extremity.

Towing another vehicle: Shall have separately displayed thereon the lights required herein to be displayed on vehicles of the class to which it belongs.

Motorcycles, tricycles and bicycles: One white light in front visible at least three hundred feet.

Colored lights: Shall not be shown to the front of any vehicle.

Glaring headlights: Not permitted on any street, avenue or boulevard in the city.

Inspection: The commissioner of streets shall pass upon the practicability of any side or head light and shall have authority to issue certificates of inspection.

Smoke and Accidents.

Opening of **muffler** or other excessive noise is prohibited, also the emitting of smoke, steam, or noxious gas or vapor.

In case of accident, driver shall stop and give what assistance he can, and shall give his name and address and the name and address of the owner of the car and license number.

How to Drive.

All vehicles must be driven in a careful manner with due regard for other vehicles and persons. If overtaking another vehicle, pass it on its left side (except street cars); in meeting another vehicle, pass it to the right; keep to the right side of the street.

Speed shall be governed by conditions and may be deemed reckless even though within the limit allowed by law.

Two vehicles moving abreast shall not be overtaken and passed.

Vehicles shall not leave the line on the right unless there is a clear way of at least one hundred feet in advance on the left.

In crossing from one side of the street to the the other, a vehicle shall do so by turning to the left.

If street is not wide enough to turn without backing, go to the next corner or proceed around the block.

Do not drive within ten feet of any vehicle when approaching and passing over a crossing.

Police, fire department, underwriters' salvage corps, emergency repair vehicles of street railways and the public lighting companies, United States mail vehicles and ambulances shall have the right-of-way in any street and through any procession, when in the regular course of their proper duties.

The driver of a street car shall immediately stop said car and keep it stationary upon the approach of a fire engine or other fire apparatus.

The driver of a vehicle on the approach of a fire engine or apparatus shall immediately draw up said vehicle as near as practicable to the right-hand curb, and parallel thereto and bring it to a standstill.

Drivers of horses must have reins in hands at all times; if walking, must keep within reach of bridle.

No one shall drive a public, numbered, licensed or business vehicle who is less than 16 years of age.

No person shall drive any vehicle the width of which, with its load, exceeds ten feet.

Drivers must at all times comply with any direction, by voice or hand, of any member of the police force, as to stopping, starting, approaching or departing from any place; the manner of taking up or discharging passengers or loading or unloading goods in any place.

No person having charge of a vehicle shall stop the same abreast of another vehicle lengthwise of a street, except in case of emergency.

Every bicycle, motorcycle, automobile, ambulance or emergency vehicle shall be equipped with a suitable signaling device to warn pedestrians or other vehicles when necessary.

Pedestrians have the right to cross the street in safety, but the streets are primarily for traffic, and by observing the rules, pedestrians will facilitate the movement of traffic and minimize the danger to themselves.

Pedestrians before stepping to the street from the curb, should look in both directions for vehicles.

Pedestrians should cross the street at the regular crossings and at right angles and should not cross in the middle of the block, or diagonally at intersections.

When waiting for a street car, stand on the sidewalk until the car approaches.

In the congested district, drivers will stop their vehicles back of the building line, when signaled to stop by the traffic officer.

No vehicle will be allowed to stand on any street nearer than 48 feet from the building line of intersecting street where street cars take on or discharge passengers.

Drivers of vehicles shall designate the direction in which they wish to proceed. This may be done by signal or by word of mouth.

Slow moving vehicles shall be keep to the right and as near the curb as practicable. Rapidly moving vehicles shall keep to the right and such distance from the right-hand curb as will allow them to pass slow moving vehicles.

---

*St. Louis Ordinances as an example. Not revised since 1917, changes have been made.

Safety First—Read and Remember.

The following is an advertisement in which Chicago manufacturers, public service corporations, financial institutions, insurance companies, firms and individuals co-operated. It speaks for itself.

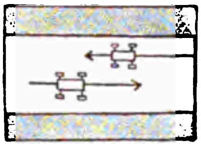


Fig. 1—Cars going in opposite direction; keep well to the right.

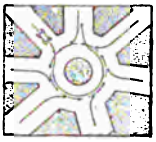


Fig. 2—On approaching a circle; arrows point the way

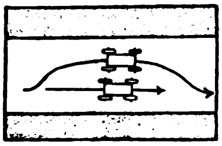


Fig. 3—One car passing another vehicle going in the same direction.

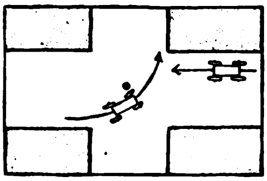


Fig. 4—In turning corners with a car coming, use signal with your hand to indicate the direction you intend to go and for him to slow up. Always observe a central point O in the intersection of streets and clear it when turning.

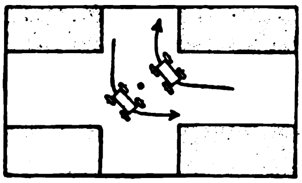


Fig. 5—The driver of a vehicle turning to the left from right hand side; should pass the center of the street intersection before making a turn. In case he wishes to make a right hand turn he should hug curb as closely as possible.

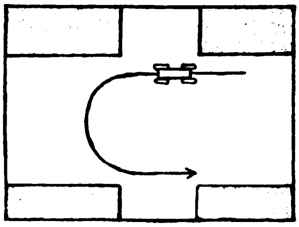


Fig. 7—Turning, go to the far corner; then make a wide swing to turn.

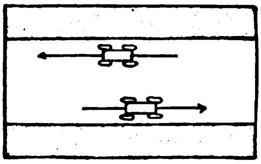


Fig. 6—In stopping, do not face car in wrong direction. Stop with the right side of car to the curb

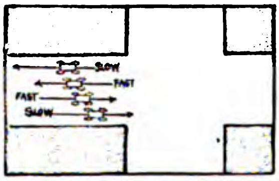


Fig. 8—Slow going vehicles; keep close to curb.

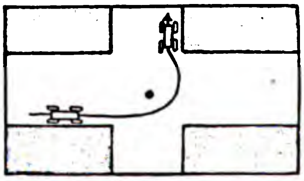


Fig. 9—How an auto should turn a corner

Don'ts for Drivers.

Don't approach street intersections at high speed.

Don't resent the traffic officer's directions—he is doing his best to prevent accidents.

Don't overlook the rights of the pedestrian—his life is just as important as yours.

Don't fail to give signal with hand when turning or stopping.

Don't drive on the left side of street or cut corners.

Don't permit your chauffeur to speed. You are just as guilty as he.

Don't use your big headlights—they blind other drivers and pedestrians.

Don'ts for Pedestrians.

Don't cross streets before looking both ways.

Don't stand in traffic route when waiting for street car. Remain on sidewalk or in safety zone.

Don't cross street except at the regular crossing.

Safety for Children.

Don't cross a street without first stopping and looking both ways.

Don't play in the street, especially in one frequently used by automobiles.

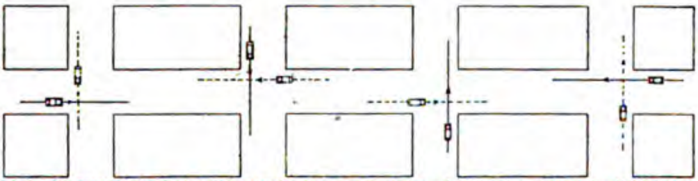
Don't steal rides by hanging on the back of wagons, trucks, automobiles.

Don't throw a stone or other missile at any vehicle.

Don't use roller skates or coasters on the streets.

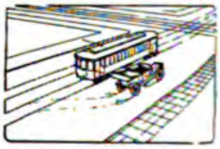
Don't ride on the left side of the street and near the curb while riding a bicycle—stay on the right side.

Don't catch on to automobiles when riding bicycle.

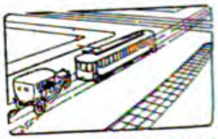


It is the rule in many cities that when two vehicles approach a street intersection simultaneously, in the manner illustrated, the vehicle at the right, as indicated by the heavy lines, shall have the right of way, regardless of the direction it is traveling

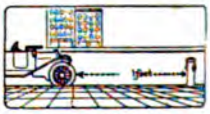
It is the rule in many cities that when two vehicles approach a street intersection simultaneously in the manner illustrated, the vehicle at the right, as indicated by the heavy lines, shall have the right of way regardless of the direction traveled.



The right way to pass street cars is the right way



Passing a street car at the left, a violation of the law



Cars must not be left near hydrants

CHART NO. 218—Rules of the Road in Driving Straight Ahead, Passing and Turning.

*One-Way Streets.

Sixth, Seventh, Eighth and Ninth streets, from Washington avenue to Market street, are designated as one-way streets from 7 a. m. to 7 p. m.

Sixth and Eighth streets between the hours mentioned, vehicular traffic will move south on east side of street. Waiting vehicles will stand on the west, facing south, and at an angle of 30 degrees with the curb.

Seventh and Ninth streets between the hours mentioned, all vehicular traffic will move north on the west side of the street. Waiting vehicles will stand on the east side, facing north and at an angle of 30 degrees with the curb.

License and Right-of-Way.

City license plates shall be displayed on the dash or on the right-hand side of the vehicle, and securely fastened so as to prevent from swinging, in plain view, free of obstruction.

State license plate shall be conspicuously displayed upon and permanently fixed on the back of every motor vehicle. License plate to be kept clean of mud or dust.

Right-of-way: East or west-bound vehicles shall have the right-of-way over north or south-bound vehicles.

Divided streets: Keep to the right of parkways or other divisions or obstructions in the middle of streets.

Miscellaneous.

Persons under the influence of intoxicating liquor shall not drive any kind of vehicle. Driving while intoxicated shall be construed as reckless driving.

The driver of every vehicle shall stop such vehicle and remain at the rear of any street car which has stopped to take on or let off passengers, so as to allow passengers free passage between the street car and the curb, and the driver shall cause his vehicle to remain standing until such street car has resumed motion; provided that in the congested district vehicles may pass street cars stopping if they clear six feet from the lower step of running board of the street car, otherwise such vehicles shall stop as herein provided; but this section shall not apply to vehicles passing street cars headed in an opposite direction.

Safety zones: Do not drive within a safety zone.

Turning to right: Turn as close to the right-hand curb as practicable.

Turning to left: Turn beyond the center of the intersection of the two streets.

Speed of motor vehicles: In business districts, eight miles; in other portions of the city, ten miles. In coming out of driveways, move very slowly, not faster than a walk.

Speed in parks and boulevards: Not to exceed six miles.

Speed at street crossing: Slow to one-half speed when crossing main thoroughfares, or in turning thereon and sound proper signals.

Signal upon turning: Make sure it is safe to turn and give signal of intention by extending hand or otherwise.

Warning when stopping: Extend hand to warn following machines.

No testing in parks: Motor vehicles may not be driven in parks, parkways or boulevards for the purpose of testing the machines.

Processions: Not to be driven through except with permission of a police officer.

Slowly moving vehicles: Keep to the right-hand curb in single file, not two or more abreast.

Blockade: No vehicle is permitted to willfully blockade or obstruct any street by standing therein, by the manner in which it is driven, or through overloading.

Fire hydrant obstruction: No vehicle unattended shall be left standing at any time within six feet of a fire hydrant.

Brakes and horns: All motor vehicles shall be provided with adequate brakes and suitable bells or horns.

How long may stand: May stand not more than two hours between the hours of 7. a. m. and 7 p. m. in the congested district of the city. (Ordinance 28,807.)

**Congested District.

Fourth street between Washington and Chestnut.
Broadway between Washington and Market.
Sixth street between Washington and Market.
Seventh street between Washington and Market.
Eighth street between Washington and Market.
Ninth street between Washington and Pine.
Tenth street between Washington and Pine.
Market street between Fourth and Eighth.
Pine street between Third and Tenth.
Olive street between Third and Twelfth.
Locust street between Third and Theresa.
St. Charles street between Fourth and Tenth.
Washington avenue between Fourth and Ninth.
Grand avenue between Lindell boulevard and Morgan street.
Third street, Locust to Chestnut.

Any vehicle wishing to make complete turn must drive around the block.

Spaces designated by signs, placed by the director of streets and sewers, shall in congested district be used only for loading or unloading passengers or freight. In no event shall such space be occupied longer than 15 minutes for any purpose and vehicles not allowed to park in said space.

Time fixed by ordinance: Seven a. m. to seven p. m.

Meaning of verb "to park" as used in ordinance: To park means to stand or store a vehicle on a public highway when not being loaded or unloaded.

Time limit for parking: Parking is limited to two hours in congested district, except when a vehicle may be broken down or standing for hire at authorized places.

Vehicles used for advertising purposes of any kind shall be kept continuously on the move at a rate of speed exceeding three miles an hour. This applies to vehicles being advertised for sale.

Parking in front of entrance of public building: No vehicle shall be parked before an entrance to a public building for a longer period than thirty minutes.

Punishment: Any person violating the rules within the hours fixed shall be deemed guilty of a misdemeanor, and upon conviction shall be fined not less than five nor more than five hundred dollars.

Cross-walk obstruction: Not permitted to stop on cross-walks so as to obstruct free passage on them.

Vehicles unattended: Must have motor stopped, or on electric machines controller switch locked and key withdrawn.

Bicycles: Not to be ridden on sidewalks except on unpaved streets in an impassable condition, then not over five miles per hour.

Hitching: "Hitching on" any vehicle not permitted either with or without the consent of the driver thereof.

Horses to be turned: The horse or horses attached to a vehicle back to the curb shall be turned at right angles to the right.

Unattended horse-drawn vehicles: No person shall leave any animal standing in any public place without being fastened or so guarded as to prevent its running away.

System of Signals.

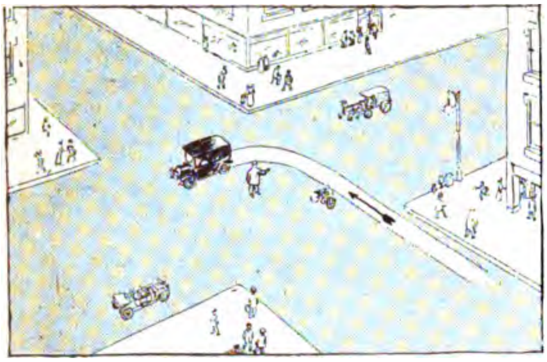
A traffic officer is stationed in the center of the street, or as near thereto as possible, and signals traffic by extending his arms in the direction in which he desires traffic to move. Thus, when the officer faces north or south and extends his arms to the east and west, east-bound and west-bound traffic moves. North-bound and south-bound traffic meanwhile is at a standstill and remains so until signaled by the officer, who does so by changing his position to face east or west and extending his arms north and south.

Turns are made as follows: A driver north-bound desires to turn west. The officer signals him by forming a right angle with his arms, one pointing south and the other west and vice versa.

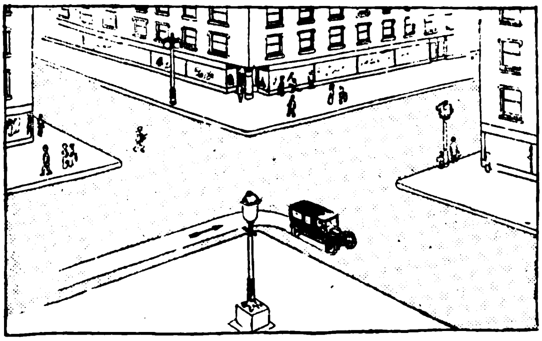
Locking: Motor vehicles shall be provided with good and sufficient lock, to be installed in a manner that will allow the towing or moving of the car when necessary by the police or fire departments.

**Traffic ordinances similar—are provided free to motorists in every large city. When touring, one should secure a copy of each large city he enters.

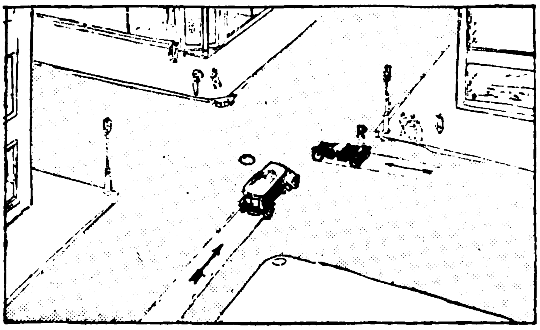
*One way streets are usually those in which street cars run in one direction only. Alleys in business districts are also one way. In all east and west alleys, vehicles shall move west and all north and south alleys move south.



When turning to the left—pass around the center of intersection of two streets.



When turning to the right keep near right hand curb.



On crossing a street—the right hand vehicle has the right of way

Rules For Driving.

Approaching rail roads—In approaching a railroad crossing, especially if there is an incline or grade, the car should be dropped back into second speed and the approach made carefully, first to determine whether to make the crossing or not, and second, to be in position to accelerate your car suddenly with very little chance of stalling your engine.

Many accidents have happened because inexperienced drivers have become confused and stalled their engine. On noting the approach of the train, they have thrown on their power, or let in their clutch suddenly with the result that the engine is stalled and it is then too late to move out of danger.

In crossing street car tracks and climbing out of ruts—skidding can be prevented and accidents avoided, also the life of your tires lengthened, if you will learn how to turn your car out of street car tracks and ruts. Make a sharp turn of your front wheel. Do not allow the wheel to climb along the edge of the rut and finally jump off suddenly, and do not attempt to climb out of these conditions at speed.

Rounding corners at speed—Driving a car around a sharp corner at twenty-five miles an hour does more damage to the tires than does fifteen or twenty-five miles of straight road work. This is an economical reason why one should drive around corners cautiously and slowly. The other reasons are obvious.

In passing a slower moving vehicle going the same direction, always pass on the left, so it is to your right. If you attempt to pass on his right, you may be run into the gutter. **In passing another car going the same direction, don't run immediately in front of it.** More accidents have resulted from this practice than in any other manner.

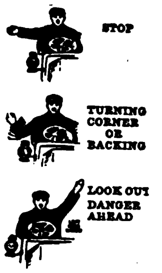
When a car comes up from behind, and shows signs of desiring to pass, give it the road by swinging to the right. Before starting to race it, remember that it is about the most dangerous thing that can be done, and that racing has caused many automobile accidents.

In passing street cars, never pass it on the left, but on the right—another car may be coming the opposite direction (if double track which is usually the case) you would then be bound to place yourself on the wrong side of the street.

If passengers are getting on or off cars—stop, don't crowd between them and the curb, its against the law in most cities. **Do not follow a car too closely**—it may stop suddenly, without warning.

Stop when there is an accident, whether it is your fault or not. Render all the assistance possible, and as a safeguard get the names and addresses of witnesses.

Excessive sounding of the horn is proof that the motorist is a novice. Sometimes in the presence of a frightened horse, it may be better not to use the horn at all. No accepted rules exist in regard to the meaning of horn blasts, but it is reasonable to assume that prolonged honking indicates that the car behind is going to pass and desires a clear road.



If you are driving in front of another signal to the party behind you as above when stopping, slowing down or turning.

Remember: That a nervous driver may pull the wrong rein. That a pedestrian cannot make up his mind in a hurry when he wants to cross the road. That it is your business to avoid danger, not the other man's. That the road is free for all, and that it pays to be courteous.

Use of head lights: Do not use the electric head lights turned to the "bright" position when approaching or passing a car or other vehicle on a narrow road unless you are traveling in the same direction. The light confuses them and may result in a serious accident.

Headlight Courtesy on the Road.

You know how very difficult it is to see when you are approaching another machine with glaring headlights. You are simply blinded and cannot tell whether you are running off the road, are too close to the oncoming machine or are striking obstructions. It is a peculiarly helpless feeling to be directing a car when confronted by the other fellow's glaring lights in this way.

If your headlights are on, he is in just the same predicament, however, and it is the least either of you can do to dim the headlights while passing. This is a safety factor as well, for it protects both from running into one another or off the road.

In most states a law prohibits the use of glaring headlights—see page 433.

IART NO. 219—Rules For Driving. Signals for the Motorist Behind.

INSTRUCTION No. 36.

CARE OF CAR: Pointers on Driving, Washing, Polishing, and Cleaning Car. Home Made and Other Polishes. Painting a Car at Home. Systematic Car Inspection. Shipping.

General Pointers on Driving and Care of the Car.

The driver must keep his eyes and ears open, watching the other occupants of the road as well as the running of the car.

The ear is the best judge of the running of the engine, as it shows any defect by a change in its steady throb. With practice it becomes easy to recognize a new noise and the cause should be located and remedied at once. A squeak or rattle that comes at regular intervals may be located in one of the revolving parts, and if not regular, it comes from something that is not revolving—the springs, brakes or similar part.

Irregular running of the engine may not be serious, but rather the result of a rough road or loose ignition connections. **Knocks or pounds should be located at once,** for they may lead to serious breakdown.

Know Your Car.

Remember that in the care and operation of a motor car, much must be left to the judgment of the operator, who should study the construction of his car and thoroughly acquaint himself with its mechanism, the functions of its various parts and the why of everything connected with it.

Learn the speed of which the car will take a turn on mud or wet asphalt, without skidding or side-slipping, and never exceed it. Learn the grade of a hill that the car will climb easily, and on steeper grades do not wait for the engine to labor before changing the speed.

Learn the turn that it will make for every position of the steering wheel, and always make the broadest turns that the width of the road will permit. A sharp turn is more likely to strain and injure the tires, running gear and steering mechanism, than a broad turn, and if the car is speeding, more likely to cause an upset.

Learn the distance that the car will travel before refilling the tanks—not from the catalogue, but from your own experience, so that hold-up on the road for supplies may be prevented.

Learn the rapidity with which the car will pick up speed after a slow-down, as it will help when running through traffic, or when it is necessary to dodge another vehicle.

It is important to learn the shortest distance in which the car can be stopped for its different speeds, and the exact amount that it slows down for each application of the brakes. Learn to use the brakes so that the motion becomes automatic, and can be done without wasting time thinking about it. Learn to judge distance, and the speeds at which the car travels; ability to estimate speeds may prevent arrest.

Learn to recognize the noises of the engine when it is running smoothly; the click of the valves, the hum of the timing, pump and magneto gears, the puff of the exhaust, so that unusual noises may be easily recognized.

Learn the feel of the compression, by cranking the engine, so that leaks may be detected. Learn the effort required to push the car on a smooth floor by hand, so that a binding brake or a tight bearing may be felt. In short, get in tune with your car—be part of it—make it part of you; that is, if you want to get good service from it, and save on the repair bills.

Something to Remember.

The flashy driver, who makes quick turns and sudden stops, attracts attention, but ruins the car. The more smoothly a car is operated, the longer it will last, and the less often it will get out of order. Driving is not a thing to worry about, but to be taken easily.

Easy turns, gentle stops, the running of the engine as slowly as possible for the speed desired, proper adjustments, and constant care, mean long life to the car, and freedom from trouble.

When the engine is not acting right, do not rush in and re-adjust the ignition or carburetor without first being sure that the trouble has been correctly located. Throwing the carburetor out of adjustment on a guess makes it all the harder to get going again, for its re-adjustment must be added to the trouble already present. An automobile is not difficult to handle, but neither is it so simple that brain work is not necessary. Get all of the facts possible before doing anything to the mechanism—the noise that the engine made in stopping, the way it stopped, the reasons for the unnatural noises, and the bolts from which nuts may have dropped off. An automobile is constantly in a state of severe vibration, and almost any part is liable to work loose when least expected.

Some accessories are convenient, and others are nuisances. Do not load the dash up with devices that are not of practical use, for they only add to the parts that must be watched and taken care of. Provide the car with a good horn, and use it well when necessary, but never needlessly.

The lubrication is important and must be watched carefully; it takes only a little running without oil to cut the cylinder walls and piston rings. Excessive oil in the crank case means fouled spark points, and should never be permitted, however, it is better to have too much than not enough.

In running, keep to the right, and in meeting another vehicle turn farther to the right, so that it will have room to pass. (See charts 218 and 219).

In passing a vehicle going in the same direction, pass so that it is on your right, and do not swing back to the right side of the road too close in front of it. The other vehicle may speed up as you pass, and be closer than you realize.

Get thoroughly familiar with the different speeds, so that there will always be time to stop when necessary. Keep your eye on the people alongside of the road, for they may start to cross without warning. Children are liable to run out of a gate or cross the road, when they are least expected. Cross roads and cross streets must be watched, for vehicles or people may come along them.

It is dangerous to run over a dog, for the steering mechanism may be broken or the car upset. It is far safer to slow down when one is barking in front of the car than to try to push it out of the way.

Blow the horn when approaching a turn in the road, for another car may be coming. Do not run on the low speeds if it is possible to run on the high.

Save the Tires.

If a tire blows out, do not jam on the brakes—cut off the power and let the car coast to a stop. Jamming on the brakes might cause a skid, and that would fatally ruin the tire.

In crossing loose or broken stone as on a new road, do not drive the car over, but get up speed and as it strikes the stones throw out the clutch so that it will coast. If the car has not enough momentum to cross, let it go as far as possible before again throwing in the clutch. Driving across sharp stones forces the wheels to grind against them, while if the car moves without being driven, the tires roll over the stones, and are not so liable to injury.

Jamming on the brakes grinds the tires, and wears them as nothing else does. Letting in the clutch quickly, so that the wheels spin before taking hold of the road, has the same effect.

Tires that are not sufficiently inflated will rim cut and are more liable to puncture than if blown up hard. Oil rots rubber; therefore, keep the tires clear from it. If they get oily, wipe them with a cloth soaked with gasoline.

If the car is to be idle for a week or more, jack up the wheels to take the weight from the tires—it will be better for them.

Rusty rims cause rim cuts; therefore, keep them smooth. When rim rusts, scrape them or rub with emery cloth and give them a coat of shellac or lead paint to prevent them from rusting again.

In applying new tires, put them on the rear wheels, moving the half-worn one to the front wheels—this will give them a longer life. In applying a single new tire, put it on the right hand rear wheel, as this is the one that has the hardest work, and needs to be stronger than others.

An extra inner tube should always be carried, ready to insert in case of a puncture. Take out the old tube and put in the extra, then have the damaged one vulcanized. It does not pay to cement a patch on a tube; have it vulcanized. The best plan is to have demountable type of rims and carry a complete extra tire inflated, ready to mount on wheel.

Skidding ordinarily occurs only on slippery surfaces and in rounding turns at high speed. In skidding, the wheels of the car slip on the ground, especially on wet asphalt, although the car will occasionally slide on dry surfaces, like sand, loose gravel, etc. See page 495 for "skidding."

A Few Words About Gasoline and Fire.

Gasoline must be handled with care and common sense. It is dangerous if handled carelessly but need not be so if the operator uses judgment. Gasoline vaporizes easily and as the vapor is heavier than air, it sinks to the ground.

When filling the tank, be sure that there are no open lights near, or a fire. If the tank is to be filled at night, don't use a lamp, use a pocket electric flash lamp instead. Have a funnel for gasoline and do not use it for anything else. Also see index for "gasoline."

***In case of fire, do not try to put it out with water,** for the burning gasoline will float and spread the fire. Always keep a pail or two of sand handy and smother the flames with it. In case of fire, the first thing to do if it is possible, is to turn off the supply cock from the tank to the carburetor, and then push the car away from the blazing gasoline on the ground. Do not let a pool of gasoline drip from the carburetor when priming it as a chance short circuit may give a spark that will set it on fire.

---

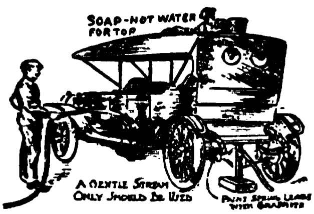
*Fires are usually caused by dripping gasoline from carburetor and a stray ignition spark. Be careful the carburetor does not drip. See also pages 158 and 161.

***Engine bearings:** After an automobile has run a great many miles the crank shaft ("main") bearings wear and allow play as also do the connecting rod bearings. The first evidence of a worn bearing is an "engine knock." **To test bearings** grasp the fly wheel and jerk it vigorously; if play is discovered it is an indication that the bearings should be "taken up." The bearings are "split," that is, arranged in two halves bolted together, see page 74. Between the halves, "shims" (very thin strips of metal) are placed. As the bearings wear, one or more shims can be removed and the bearings drawn up.

See also pages 203, 793 and 651; "running in a new engine" and page 489 for "running a new car."

Tighten bolts and nuts: It is very important that you should go over your car periodically and tighten up all loose nuts and bolts. This should be taken care of especially during long hard tours and about once a month under average driving conditions.

Washing Car.


SOAP-NOT WATER FOR TOP
A GENTLE STREAM ONLY SHOULD BE USED
PAINT SPRING LEAVES WITH GRAPHITE

First dust off the car and top, then wash car using only clear water. If soap is used, get a good carriage soap that has no alkali in it. If it contains alkali it will take off the varnish.

Mud should not be rubbed off for the varnish would be scratched. Let the water run gently out of the hose (using no nozzle) and flow over the mud, so that it washes away slowly.

The full force of the water may be used to remove mud **from under side of fenders; but not from any varnished part.** If a hose cannot be used, pour the water on so that the mud is carried away. Dry mud is more difficult to remove, but if the varnish is to be kept bright use only the above method, and take time to it.

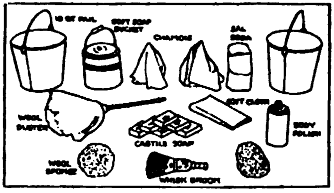
When the body is clean, go over it with a soft sponge using plenty of water and dry it with soft, clean chamois skin or wash leather. It is advisable to have a sponge and chamois skin for the running gear and a separate sponge and chamois skin for the body.

After having washed the body it should be gently dried with a piece of clean chamois skin. Wring out the water from the chamois as the car is wiped with it.

For removing grease, a sponge with castile soap and tepid water should be used and then body polish applied.

A car ought to be washed and chamoised off immediately if rained upon, otherwise spots will remain if left to dry. See Instruction 45 for "a home made washer."

Supplies for cleaning the car: Two good clean soft "wool" sponges, two ten-quart pails, several clean soft chamois, a quantity of canton flannel, a quantity of ivory or pure castile soap, clear running water, a soft wool duster, gasoline for use in extreme cases.



The two sets of pails, sponges and chamois are recommended so that the pail and sponge used for the first washing, may be kept separate from those used in the final washing.

Washing Radiator.

When it is necessary to clear the radiator spaces of accumulated mud you should flush the radiator from the rear, not from the front. In that way you avoid getting water into the magneto, which is often short-circuited when moisture enters it.

Sponge off your Hood.

Particular attention should be given to the hood after the car has been run in a heavy rain, inasmuch as after a long run it becomes fairly hot and if rain-drops are left to dry upon it they will stain it much more than the body. The car should be washed down at once, or if this is not possible, the hood should be sponged off and wiped dry immediately.

A good body polish will remove grease and rain spots from a hood or body.

**Body, Metal and Glass Polishes.

Polishing body, removing rain spots and grease: A much recommended polish is made by mixing the following ingredients; turpentine 1 gallon, paraffine oil 1 pint, oil of citronella 3½ ounces, oil of cedar 1½ ounces. This should be applied after the car is washed and dried. Apply this with soft, clean cotton waste and rub dry with a clean flannel cloth. If not rubbed dry the dust will collect. This preparation in most cases will remove rain spots and grease.

**A very satisfactory body polish and cleanser is called "Auto Liquid Veneer," which is sprayed over the dust, dirt, etc., and wiped off with a piece of cheese cloth. It can also be used on the windshield or leather cushions and leather or rubber top. Manufacturers are Buffalo Specialty Co., Buffalo, N. Y. *See pages 640 and 641.

Another method is to use a mixture of boiled linseed oil and turpentine, applying it sparingly and rubbing absolutely dry. The use of these polishes will restore even an old car to a degree of brightness that will surprise you.

Another body polish that is highly recommended is made by using 1 gallon of soft water, 4 ounces of ordinary soap, 1 pound of white wax in shavings. Boil well and add 2 ounces of pearlash. This may be diluted with water and laid on with a paint brush, then rubbed off with a cloth. Another formula often used is 3 ounces of shellac, ½ ounce of gum mastic and 1 pint of methylated spirits of wine, dissolved. In our opinion however, better results will be obtained by using some one of the varnish polishes that are on the market and can be found at almost any hardware or paint store.

A good cleanser for enameled parts of the car when parts are greasy and very dull, may be made of the following:

One pound of washing soda crystals to one pail, or 2½ gallons of water. This should be very briskly applied with a soft rag. Then polish with canton flannel.

The solution, before applying, should be carefully inspected to see that all crystals have been dissolved, as any crystals remaining will scratch the surface.

This solution should be used only on enameled parts of the car as it will ruin varnish or paint. The enameled parts of the car are the radiator, radiator splashers, bonnet, front and rear fenders, gasoline tank, tire carriers, steering column, shifter lever, black engine parts and enameled part of lamps.

Brass.

Any good brass polish will work satisfactorily. All these preparations contain some fine abrasive, for which reason care must be taken not to let the polish come into contact with the varnish body surfaces.

Nickel-Plated Parts.

All nickel plated parts may be cleaned with regular silver cleaner paste. Use only the softest flannel rag or chamois to rub with.

Do not clean lamp reflectors except when absolutely necessary and then use Putz pomade, applied with a very soft clean chamois skin. Reflectors are often silver plated and are very easily spoiled by frequent polishing.

Nickel trimmings should be rubbed over with an oily rag; that will keep them bright without polishing. When going out for a run in damp or rainy weather it saves labor to give the brass work a light coat of vaseline to protect it from tarnishing, and put rubber bags over the lamps. When there is little time to give to cleaning the brass work, paint it with black or colored enamel which looks better than uncleaned brass.

Metal and Glass Polish.

Mix one part wheat flour, five parts of dry powdered fire or potter's clay and used with a damp woolen cloth. This will be found the finest polish ever used. and is cheap. It can't be beaten for cleaning fly specks, grease, paint and other stains from glass or metal.

To Clean Glass and Reflectors.

For cleaning glass — windows, wind shields, lamp lenses, mirror lenses, etc.— there is nothing better than a mixture of half alcohol and half water, which readily will clean off dirt and leave a bright polish. With a soft cloth, or a piece of tissue paper, the work can be done expeditiously. See page 435 for cleaning and polishing reflectors. Putz pomade applied with a very soft, clean, chamois skin is also excellent for cleaning reflectors.

**Cleaning Tops.

To clean top—outside. A top that has been in use for some time can be cleaned by using the following mixture:

½ pint raw linseed oil; 4 cups water; ½ cup turpentine. Apply with clean rag and rub dry.

A dressing for leather tops: A very good receipt for the purpose: One part liquid asphaltum to two parts castor oil, to which add ½ ounce of ivory black to each pint of the mixture. Apply with a soft brush. This dressing is excellent for a rubber top.

Mohair tops should be frequently dusted and brushed off. Pantasote tops and curtains are best cleaned with a soft brush dipped in water in which a little ammonia has been added. Afterwards rub dry.

Never attempt to clean top and curtains with gasoline or kerosene.

Do not fold the top until it has become thoroughly dry, because any moisture remaining in the folds is apt to cause mildew, beside making the top leaky and unsightly with spots. When the car is not used for some time it is best to open the top, which keeps it well stretched and smooth.

If top is mohair, a pail of tepid water and a bar of castile soap should be used. Place soap in pail and work with the hands until a good lather is obtained. A large clean sponge is dipped into the water and top thoroughly washed.

If top is dirty use broom first. After cleaned with soap go over it with clear water so no alkali spots will appear.

To prevent rain or snow from sticking to glass: mix about 2 oz. glycerine with 1 oz. of water and a dram of salt. Apply to wind shield with cheese cloth—wiping up and down or in a vertical direction.

For Cleaning Engine—see index. **See also index; "Repairing Tops."

Cleaning Leather Upholstering.

Do not use gasoline in cleaning leather upholstery. Plain water with a little ammonia will remove the dirt, and a brisk rubbing with a clean woolen or flannel cloth will do the rest. For still more careful treatment, use a regular leather dressing on all leather.

Receipt for a dressing for leather upholstering: Raw linseed oil and turpentine mixed in proportions two of the former to one of the latter, is a time honored formula.

For cleaning cloth upholstery use clear water and a mixture of ¾ of an ounce of common salt and two ounces of either grain, or wood alcohol, simply rubbing the cloth with a sponge dampened in the above mixture.

To remove ordinary dust from cloth upholstery, beat cushions and backs lightly with stick or carpet beater, then remove dust with whisk broom or brush. (The vacuum plan is best.)

Grease or oil may be removed by the application of a solution of luke warm water and ivory soap, applied with a woolen cloth. Any of the approved methods for cleaning woolen cloth may be used with success on this upholstery. Gasoline and benzine have a tendency to spread instead of remove the dirt. We, therefore, do not recommend their use although they work no injury to the fabric.

*Suggestions for Repainting Car at Home.

In some cases the car owner may feel disposed to do some of the work himself, and then pass it on for the professional painter to put on the finishing coats.

He may, for example, give the car as thorough and complete a washing up as the painter will do. Then by getting the car up on stout wooden horses, so that he can work under it conveniently the grease and dirt may be removed from the chassis. This is a somewhat smeary job but anyone who isn't afraid of work can save some money by doing it. Saturate the greasy parts with one-third turpentine and two-thirds kerosene or crude oil, and let the applied mixture stand for several hours to soften up the hardened oil and dirt.

Then take a one-half inch putty knife and a couple of mowing machine knives and some pieces of coarse burlap and proceed to cut and scrape the accumulations off and wipe the parts up. It may take two or three applications of the oil and turpentine mixture, and a lot of rubbing with the burlap to get the surface clean, but it is all necessary work.

If the surface is worn and the paint beaten off, and the bare metal or wood disclosed, these pieces will need touching up with a paint mixture containing at least one part raw linseed oil and two parts turpentine. Mix thoroughly, some ground white lead and lamp-black and add a little at a time to the oil and turpentine. Apply with a small round brush.

Next get some dry white lead and a small quantity of finely ground whiting, and using one part of the whiting to two parts dry white lead, knead it to a good working body in equal parts of coach japan and rubbing varnish. Then with your putty knife, putty up all the holes and surface fractures, filling them smooth and level with the surrounding surface. While this class of work is somewhat difficult to do well, with care and some practice it may be taken care of.

If the surface is in a condition suitable to sand paper, apply the color without any further surfacing. The professional painter may then, if so desired be called in to sand this putty and the surface down smooth and apply a coat of color to the car. If any striping is to be applied, the lines may be run on this coat of color after which apply one or two coats of varnish, according to the class of finish desired.

In case the car needs simply a coat of varnish, with perhaps a few worn or bruised spots touched up with a bit of color, it should first receive a thorough washing and cleaning. The body surface will need going over with water and pulverized pumicestone to lay down the gloss and fit it for the varnish. Then touch up with the color where necessary, and apply a coat of body finishing varnish. Likewise, give the chassis a stout coat of varnish.

In this connection, it may be stated that the amount and kind of work to be applied to the car depends altogether upon the condition of the surface at the time the work is to be done, as it naturally also depends upon the sum of money the owner wishes to expend upon the work. Generally speaking, if the car is kept well varnished, it will not need heavy painting repairs only at long intervals.

**Painting Radiator, Engine, Cylinders, Manifold, etc.

To paint radiator, mix 8 oz. boiled linseed oil. 4 oz. lamp black, 1 oz. turpentine and thin down with turpentine to the proper consistency. In applying, the radiator must be either dipped into solution (in this case a great deal more must be mixed), or sprayed (see page 194 and index; "painting radiator,") or the radiator can be placed on boxes, face up and with a thin mixture as above, applied plentifully so it will run through the cellular parts of radiator. A camels hair brush can be used to reach places not covered.

†To paint cylinders, mix 8 oz. white lead in oil, 6 oz. boiled linseed oil, 2 oz. turpentine and ½ oz. of lamp black. If too heavy thin down with turpentine. This will make a gray paint and sufficient for 6 cylinders.

Aluminum mixed with bronzing liquid can also be used.

To paint intake manifold—use regular aluminum secured at any drug store.

To paint exhaust manifold—use aluminum. No paint has as yet been found which will remain on hot exhaust pipes; here is a recipe suggested:

Heat proof paint—use two parts of black oxide of manganese, three parts of graphite and nine parts of Fuller's earth, thoroughly mixed, to which add a compound of 10 parts of sodium silicate one part of glucose and four parts of water, until it is of such consistency that it may be applied with a brush.

*****Tire paint, liquid rubber** is a preservative and beautifier of tires. It gives the tire a white coating. It is made of pure unvulcanized rubber in solution. It can be applied with a brush and if used at regular intervals, it is claimed it will prolong the life of the tire because it penetrates and runs into any small cuts or holes and seals them over, thus in a measure preventing moisture from reaching the fabric. It is also suitable for golf balls, rubber mats, and a highly satisfactory rust preventive for rims. Secured at supply houses.

**See index for these various subjects. See also index; "top repairing." †See also page 588.

A very satisfactory tire paint for finishing the inside of a tire after repairing may be made by mixing thoroughly one gallon gasoline, one half pint O-85 cement, 1¼ pounds soapstone and ½ pound whiting. Many successful repairmen are using this formula with the best of results.

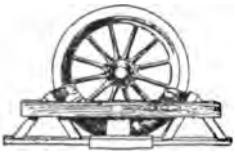
***See page 571; how to make paint to paint inside and outside of tire.

Pointers on Shipping an Auto.

An auto will only be received for transport by freight either crated or set up. The usual method in shipping by freight is to ship it complete and run it right into the car; see that the railroad company block the wheels so that the auto will not pitch forward or backward. It is also well to see that the machine is braced from the side.

Get a clear bill of lading from the railroad company so that you have something to secure damages with in case of car being smashed. It is well to box the cushions and all loose parts separately. The charge for conveyance must be ascertained by the railway company

Place the vehicle in the car parallel with the sides; and see that the front wheels are in line with the back wheels. Wrap the lower third of the tires with burlap to prevent chafing; and set the brakes.



To block wheels, fasten each wheel to the floor with a strong band of canvas or several layers of burlap of the width between two spokes. Secure the band to the floor on each side of the wheel with blocks 2 by 4 by 12 inches. Place these blocks parallel with the wheel, using plenty of nails or spikes.

Use blocking in front and behind each tire one-third as high as the diameter of the wheel and at least one inch wider than the tire. Fasten this securely to the floor and tie together with one or two-inch lumber from block to block. Have the blocking of sufficient width so that the boards used to tie blocks together will clear the tire at least one-half inch on each side.

In packing the auto, empty the gasoline and water tanks and disconnect the batteries, if electric cars, remove batteries.

The tires should be tightly inflated; and the edges of the boards and blocks next to the tire should be rounded or beveled, so that if they should become deflated or in any way come in contact with the boards or blocking, they will not be so liable to chafe. Place covering over the vehicle to keep off dust. Also remove lamps to prevent damage to them.

Freight cars should be carefully inspected to see that they are fit for loading. If there are nails or other projections in the floor or sides of the car they should be removed. If the roof appears to be leaky, or its fastenings for doors, both end and side, are not complete or ample, the car should be refused and a car suitable for loading demanded. Failure on the part of the shipper to do this renders him liable for the damages resulting from having loaded the vehicle in a car manifestly unfit.

Daily and Periodical System of Car Inspection.

Look to the following every few days:

(1) Fill gasoline tank. The funnel that is used for gasoline should never be used for water, lubricating oil, or anything but gasoline.

(2) Fill radiator.

(3) "Tickle" or prime the carburetor, to make sure that the float is free and the gasoline flowing. At the same time inspect the connections of the gasoline line for leaks and loose joints.

(4) Test the batteries, and see that the storage cells are properly filled with electrolyte. (see page 454.)

(5) See that the ignition is working properly and no miss.

(6) Lubricate the engine—See page 204. Make sure that the oil has not drained out of the crank case.

Beginning at the front of the car and working to the rear, screw the grease cups down slightly, filling those that are nearly empty.

While doing this, watch for loose nuts, and for parts that may be out of place, loose or in need of attention.

Be particular to keep the steering mechanism in good condition, and plentifully lubricated.

(8) Pump up the tires, and keep them pumped up. For pressure to use see tire subject.

(9) See that the tools, supplies and extra parts are on board.

(7) Test the brakes, (very important.)

When accustomed to it, this system will not require much time and it will result in the condition of the car being under observation at all times.

The above points should be observed for every run, but others should be attended to from time to time.

Look to the following about every week or every 1000 miles:

(1) When the car has run 1,000 miles, the crank case should be drained and washed out with kerosene. See "cleaning crank case," page 201.

Grit and dirt will work in and thicken the oil, and must be removed.

(2) Drain and wash the change speed gear case.

Constant use will grind particles of steel from the gears, and cause rapid wear.

(3) Fill the gear case so that the smallest gear dips into the oil about a half inch. See page 203.

(4) If the differential runs in oil, wash it and renew the oil two or three times a season; if it is packed with grease, one filling a season is sufficient. (see page 205.)

(5) Every 2,000 miles, take off the wheels, clean and examine their bearings, and repack with lubricant, being careful to readjust them correctly.

††Inspection Before a Long Tour:

(1) Wash and polish the car.

(2) Drain and flush out the radiator; put in fresh water.

(3) Clean and inspect the engine; change the oil in the oiling system, after draining old oil. See pages 200 and 201.

(4) Clean and adjust the clutch.

(5) Clean the gearset and add new lubricants.

(6) Clean and lubricate the universal joints.

(7) Clean, adjust and lubricate rear axle.

(8) Clean and adjust the brake—see index.

(9) Inspect and adjust the wheel bearings.

(10) Clean, inspect, adjust and grease the steering mechanism.

(11) Inspect the tires, and have cuts or injuries repaired.

(12) Clean out the gasoline tank and line, especially the strainer.

(13) Clean out engine, put in fresh oil and clean carbon—see pages 200 and 201, also index.

(14) Inspect the ignition wiring and storage battery and clean distributor points and interrupter.

(15) See that wheels and axles are in proper alignment.

(16) Adjust the carburetor and see if well tightened to manifold.

(17) Fill the radiator with an anti-freezing solution (if cold weather). See page 193.

(18) Examine and test the storage battery—see page 450.

(19) Test the compression of your engine—see index.

(20) Tighten all spring bolts and nuts.

---

††See instruction 37 for "Necessary" Accessories for Touring.

INSTRUCTION No. 37.

ACCESSORIES; TOURING: Necessary Accessories. Desirable Accessories; Speedmeters: Horns, etc. Touring Equipment. How and what to Cook. Lincoln Highway. Transcontinental Tour.

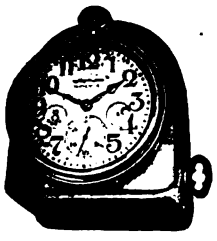
**Concerning Accessories and Equipment.

To differentiate between the accessories and spare parts actually "necessary" on a car, and those which are really only luxuries or "desirable" accessories, one has to have used them all under varying conditions and over extended periods to gain a knowledge of the desirability of each and an intimacy with their general utility.

Many a novice having unfortunately got into the clutches of an unscrupulous dealer, has bought nearly every fitting on the market being assured it is the right thing for an up-to-date car to be so equipped. Poor man! He finds it expensive work, and if the brass cleaner says little, he thinks a lot. In the beginning, be it understood that this article is primarily and exclusively intended for beginners, for I neither claim nor pretend to be able to teach the "old hands" much, as they, no doubt like myself, have learned these things for themselves.

Necessary Accessories.

‡The necessary equipment for a car should consist of: Lamp globes or bulbs, horn, tire tools, tire repairs, extra tire and tube, tool kit, jack, towrope, top, windshield, speedometer, bumper, hydrometer, odometer and a good clock.



Automobile clocks are made in many designs by Waltham Watch Co., Waltham, Mass. Note the "O" on dial. A red signal will appear every 8 days which is a notice to wind.

Though the clock is the last on this list it is very necessary, and it should be of the best and well built to stand vibration. As cars are driven in all seasons of the year the clock should have a compensating balance so that it will not be affected by extremes in temperature.

Experienced automomile drivers advise a clock to do away with the inconvenience of referring to their watch when clothed for cold or stormy weather as a few seconds necessary to do this might result in an accident to the machine or passengers.

Necessity of a speedometer. A speedometer is necessary in testing a car to learn its speed capabilities under various conditions—in order to time trips over various distances—to avoid violation of the speed limit laws, the penalty for which is arrest and fine.

Purpose of a speedometer. The speedometer for automobiles is an instrument for measuring and indicating—in miles per hour—the exact speed at which a car is being driven. The number of miles per hour shown at the dial of the speedometer is the actual speed at which the car is traveling at the instant of indication. For this reason the numbers shown constantly change as the car is driven faster or slower.

†Necessity of an odometer. The odometer is necessary in auditing the cost of operating and maintaining a car. It enables the owner to tell how much gasoline is used per mile—how much his tire expense per mile amounts to—how much mileage he gets out of his car. Thus it enables the owner to make comparison of the cost of operating and maintaining his car, with the cost of operating and maintaining a car of another make. The recording and resetting features of the trip register part of the odometer is a necessity in following a guide book when touring.

Purpose of an odometer. The odometer (combined with the speedometer) is an instrument for measuring and recording—in miles and tenths of miles—the distance a car travels in making a trip. It also records the entire distance traveled during an entire season.

Purpose of a grade indicator. The grade indicator sometimes combined with the speedometer, is an instrument for indicating the exact grades of ascents or hills negotiated by the car. This instrument would come under "desirable" and not "necessary" accessories, see also page 539.

In selecting lamps or lighting outfit, I would insist on electric light equipment with a first class lighting battery and lamps with adjustable reflectors and non-glare headlight lens, if car is not already equipped.

I would also insist on a good **jack,** not the average, as usually included with car, but a good one. The Hartford, Buckeye or Badger.

A bumper will often save the radiator and is quite often placed on the rear of car as well as in front.

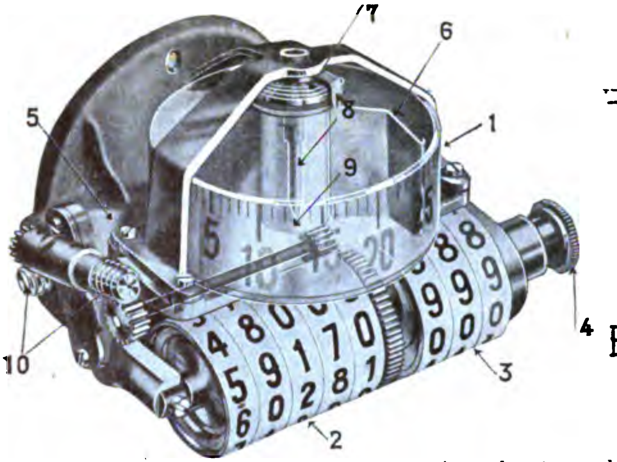
A motometer (as shown on page 188), should be on the radiator of every car.

---

*See page 349, for description of an electric clock. ‡**A gauge to indicate quantity of gasoline** in tank per page 823, would be considered as necessary.

**For accessories to sell in a garage and equipment of stock room—see Instruction 45.

†The odometer is usually embedded in the same case with speedometer.



Mechanism of Van Sicklen speedmeter showing odometer and phantom view of speed dial.

1—Aluminum speed dial; 2—Records mileage for the season; 3—Records mileage for each trip; 4—For resetting trip register; 5—Case containing air circulator gears; 6—Vane inside of speed dial; 7—Hair spring holding speed dial in position; 8—Pivot of speed dial; 9—Jeweled bearings in which pivot of speed dial is set; 10—Gears driving odometer. Tenths of miles are recorded on dial at the extreme right.

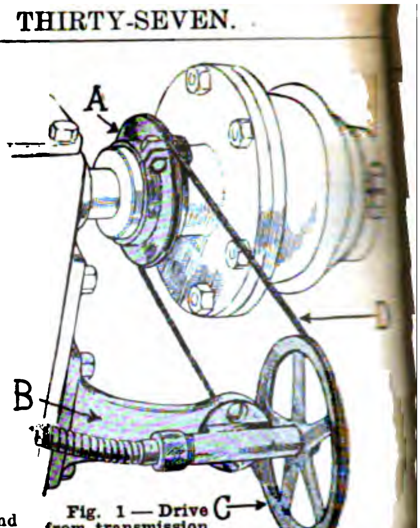


Fig. 1—Drive from transmission shaft with a wire belt.

A—Split pulley on universal joint hub; B—Bracket supporting driven pulley; C—Driven member to which flexible shaft is attached; D—Wire drive belt.

*Brief Description of Van Sicklen Speedmeter.

The Van Sicklen speedmeter is an instrument which calibrates an air current and translates the result into miles per hour. The air circulator consists of two intermeshing aluminum gears housed in a chamber in which there are two openings, one from the outside and away from which the gears rotate, the other opening conducting the air into the speed dial chamber where the air is directed against a light vane attached to inside of speed dial.

The speed dial is an inverted aluminum cup mounted on a pivot set in jeweled bearings. The amount of air directed against the vane in speed dial is governed by the speed at which the air circulator is driven by the flexible shaft. The speed dial when the car is at rest is held at zero by the action of a nickeled steel hair spring.

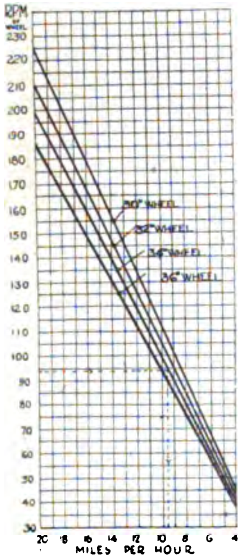


Fig. 5

Checking a Speedometer.

A simple test worked out by Mr. S. T. Williams of Motor World is shown in table below and as follows:

When the **drive is from front wheel**, jack up wheel. A chalk mark is then placed on rim of wheel and wheel turned as fast as possible.

At a signal, one person reads the speedometer, and another counts the revolutions for one minute as timed by a stop watch, or second hand of a watch. The number of revolutions of the wheel, and the speedometer reading at the start and finish are noted. (By adding the two speedometer readings, and dividing them by two, the average speed as recorded by the speedometer is determined.)

The actual speed may be obtained from the chart in fig. 5. Supposing the revolutions in the minute to have been 94, a horizontal line is followed until it meets the slanting line representing the diameter at the front wheel. Dropping down vertically, the speed is seen to be 9.6 miles per hour—which should correspond to the speedometer readings. If carefully made, this test is quite accurate, and requires little time.

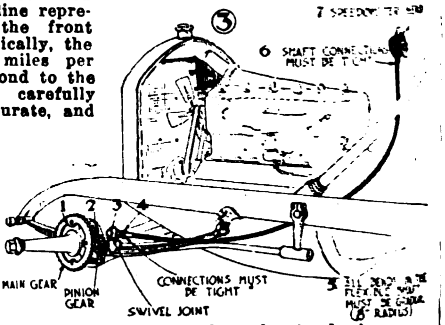

③
7 SPEEDOMETER HEAD
6 SHAFT CONNECTIONS MUST BE TIGHT
1
2
3
4
MAIN GEAR
PINION GEAR
SWIVEL JOINT
CONNECTIONS MUST BE TIGHT
5 ALL BENDS IN THE FLEXIBLE SHAFT MUST BE GRADUAL (6" RADIUS)

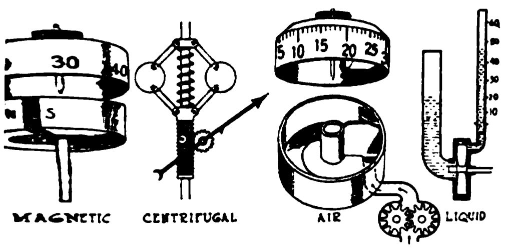
Fig. 3—Drive from front wheel.

Troubles

The indications of trouble are dial or pointer vibration, or failure of the instrument to register. Starting with the road wheel, examine the parts as per fig. 3. Begin with 1. **The head (7) is the last part to inspect.**

CHART NO. 220—Van Sicklen Speedmeter. Transmission Shaft. Checking a Speedometer for Accuracy. Speedometer Troubles.

On all Stewart speedometers the space between the main gear (1—fig. 3) and the pinion gear should be ½". Also note that the main gear (fig. 4) should have twice the number of teeth that there are inches in the diameter of the tire—see page 513. ***The Van Sicklen term their make of instrument a "Speedmeter"—otherwise term "Speedometer" is always used.**



The four principles of speedometer operation: Magnetic, in which a revolving magnet [illegible] its drag on the dial; centrifugal, in which revolving weights supply the energy due to rifugal force; air, in which a current of air flows against a vane carrying the dial, and id, in which a column of liquid is lifted a height proportional to the speed of pump drive

Speedometer Principles.

The magnetic principle as indicated in **tewart**-Warner and American Ever-Ready **nstruments**, utilizes a revolving magnet posi**tively** driven from the car wheel or other **art.** The magnet exerts its influence on a **netal** part which is separated from it by **n air** gap and which in turn is connected **with** the indicating mechanism. The metal **part is** generally aluminum, as the inertia of **the part** must be kept as low as possible to **make** the speedometer quickly sensible to **speed** changes. A feature of the magnetic **design** is that the travel of the dial bears **a direct** ratio to the speed of travel of the **magnet,** and in order to compensate for **changes** in the drag due to temperature differences, a compensating unit is fitted.

Centrifugal control as utilized in speedometers is very much the same as that on a **fly-ball** engine governor. Standard, Johns-**Manville**, Sears-Cross, Corbin-Brown, Hoff**ecker** and Garford use this principle. Weights **are** mounted on the revolving shaft by bell **crank** levers which allow them to travel fur**ther** from the axis of the shaft as the speed **of** the drive increases. The centrifugal force **of the** weights increases as the square of the **velocity** of the shaft, meaning that at four **times** the speed, the force doubles.

This tendency of the weights to fly from **the axial** center of the shaft under the in**fluence** of centrifugal force furnishes the **basis** of the indicating needle movement. An **ingenious** feature in centrifugal design is **that** although the movement of the weights **would** naturally vary as the square of the **speed,** the levers or cams governing the movement are so calculated that calibrations on the dial are uniform or nearly so. Another feature which is carefully watched is the balance of the weights. The governors are made very sensitive so that even at low speeds the correct rate of travel may be indicated.

The air principle is used on one make, the Van Sicklen, which is described in chart 220.

Liquid or hydraulic principle: One instrument, the Veeder, which employs the hydraulic system, uses a centrifugal pump which is connected with the drive and which lifts a liquid to a height proportional to the speed of the drive. The tube in which the colored liquid is lifted is calibrated to register speed. See illustration.

Speedometer Drive Methods.

Front wheel drive: The speedometer can be driven from the front wheel or off the transmission shafts as per fig. 5. The usual plan is to drive with gears but a wire belt as per, D, fig. 1, chart 220 can also be used.

Transmission drive: Instead of placing the speedometer drive on the front wheel which has been the standard former method, it is now quite often placed just rear of the transmission, on transmission main shaft. Fig. 5 shows how the driving gear is attached to the front of the forward universal joint. The swivel joint and gear section are clearly depicted. Other manufacturers are now adopting a set of gears inside of the transmission case, to drive the speedometer shaft.

Ratio of Gearing.

Ratio of gears for speedometer when driven from front wheels is found by doubling the diameter of tire and this gives the number of teeth necessary in the large **driving or road wheel gear.** For example a 30x4 tire would require a 60 tooth gear, etc. **Driven pinion** (small one) on all Stewart-Warner speedometers, for front axle drive have the same number of teeth, viz., 16, and drive through a 2½ to 1 swivel joint reduction.

The gear reduction in the swivel joint is mounted close to the driven pinion, as shown in figs. 4 and 5, and when installed on the left hand wheel, a swivel joint is used which reverses the direction of rotation.

Calibration: The Stewart-Warner speedometer flexible shaft, travels 1009 revolutions per minute when the car is traveling 60 miles per hour.

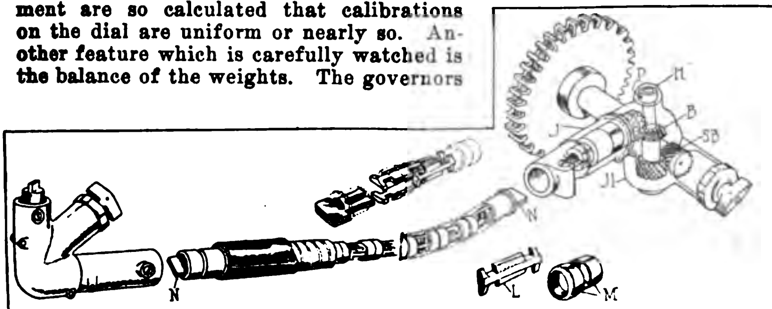


Fig. 6—Showing the flexible shaft together with other fittings, including swivel and angle joints

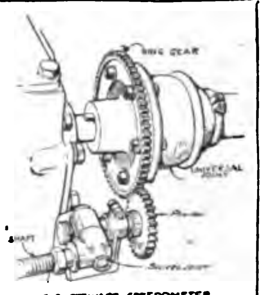


FIG 5 STEWART SPEEDOMETER PROPELLER SHAFT DRIVE

On the Waltham, which is illustrated above, (to the left), the flexible shaft is made up of a series of links, L, which are held in position by a series of steel collars M.

CHART NO. 221—Speedometer Principles Exemplified; Magnetic, Centrifugal, Air and Hydrauli

The Electric Horn.

There are two types, the vibrator type and the electric motor type.

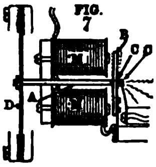
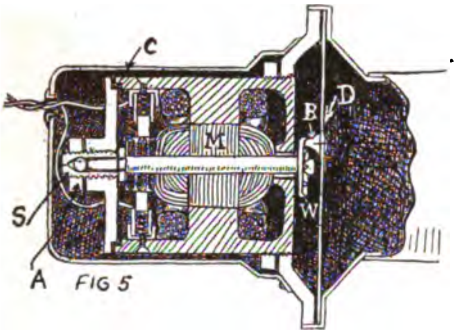


FIG. 7

The electric vibrator horn, fig. 7: There are no revolving parts. The magnets (M) cause the vibrating spring (B) to strike the adjustable rod (A) which is attached to diaphragm (D) and breaks contact at points (C C). The construction of the vibrator is similar to an electric bell as is also the adjustment. The idea being to adjust vibrator (B) in relation to rod (A) to obtain a greater or less number of vibrations (similar to fig. 1, page 234) which increases or decreases the sound.

Points (C C) should be of iridium platinum, else will wear down and stick. Amperage consumed is 4 to 6.



The electric-motor horn, fig. 5; consists of a small electric motor with armature (M), field winding, commutator and brushes. When armature revolves the glass hard toothed wheel (W) rubs the glass hard button (B) which is riveted to a diaphragm (D)—see figs. 5 and 6. It is from this diaphram that the sound is obtained.

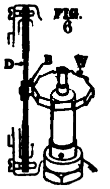


FIG. 6

The voltage required for Klaxon horns is 6 to 8 volts. A storage battery or 6 to 8 dry cells can be used.

The amperage or current consumption is fixed for each size of Klaxon horn as stated under illustrations.

If in testing horn, as per page 418, it is found that the current or amperage consumption is greater than the fixed amount, then it is likely due to dry or dirty bearings, commutator and brushes, caused by instrument not receiving the proper lubrication.

Connections can be two wire or grounded, per page 515.

*To Adjust the Klaxon Horn.

To adjust 20L, fig. 1; loosen the lock nut (A), start the current by pressing the push button. While it is sounding twist the motor case until no sound is heard except the buzzing of the motor. Continue twisting, in either direction, until note is loud and clear. When note is as desired tighten lock nut.

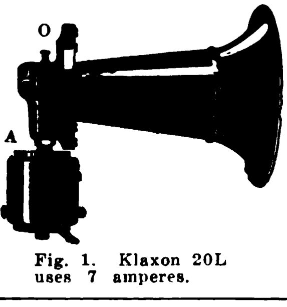


Fig. 1. Klaxon 20L uses 7 amperes.

To adjust the Klaxon 12-L and Klaxon-6, figs. 2 and 3, loosen the screws and remove cover (C). You will find a lock nut (A), fig. 5. While motor is running adjust screw (S) until the note is as desired. This action forces the armature shaft with its wheel (W) against the button (B). Replace cover and tighten screws.

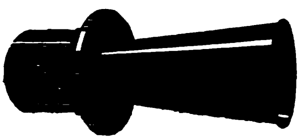


Fig. 2. Klaxon 12L uses 8 amperes.

Fig. 3. Klaxon-6 uses 5 amperes and Klaxette not shown, 3 amperes.

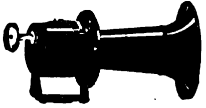


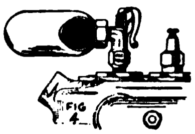
Fig. 4. Klaxon-3, hand type. Klaxon 83 type is same except it has a vertical push rack.

To lubricate; clean and lubricate commutator once a month as follows: With a dry cloth wipe commutator clean. Apply a little vaseline with a clean cloth. Use thin oil in winter. Apply this to commutator. The slightest film is all that is necessary. Every three or four months a little vaseline should be applied to toothed wheel (W). Oil shaft bearing once a month.

On the Klaxon 20-L oil once a week through oil hole (O), fig. 1. Give two drops of cylinder oil.

Miscellaneous Accessories.

Fig. 4—The Buell compression whistle, screwed into cylinder in place of relief cock, operated from seat. Mfg'd by Buell Mfg. Co., Chicago.



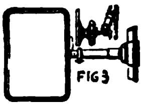


Fig. 3—A mirror useful for seeing car behind.

Fig. 5—A bumper will save lamps and radiator in case of collision. Should be on rear as well as front of car—(see page 736).

Fig. 6 — Tonneau wind shield, mfg'd by J. H. Tonneau Shield Co., 1777 Broadway, N. Y. A very desirable accessory, useful for winter or summer.

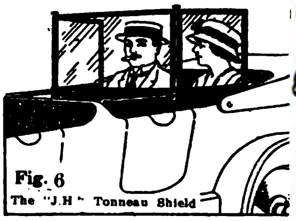
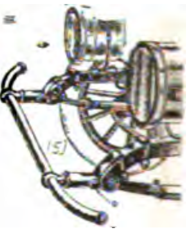


Fig. 6
The "J.H" Tonneau Shield



**The Magnetic Gasoline Tank Gauge.

These gauges are made for either pressure or gravity-feed tank; the amount of pressure makes no difference. The principle of the "Triumph" gauges is simplicity itself. A hollow metal float (F), (fig. 2), tested to one hundred pounds pressure, is threaded upon a gun metal bronze ribbon (R), which is suspended from the top of the tube and to which a permanent magnet (M) is attached.

The bronze ribbon passes through a tube in the center of the float.

As the float travels up and down inside the tube of the gauge with the rise and fall of the fluid in the tank, it is turned by a spiral cut (C) in the tube. This naturally causes the metal ribbon to make a turn, also turning the magnet which exercises its power through the solid head of the gauge, and turns the magnetic hand on the face of the dial.

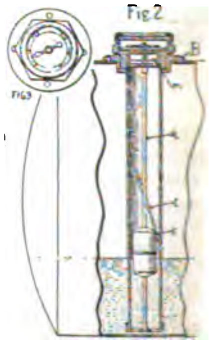


CHART NO. 222—The Electric Horn. Miscellaneous Accessories.

*See page 418, testing an electric horn. **See page 823 for the "Gasograph," a very necessary accessory.

****The desirable accessories are such as;** **shock** absorbers, which will save their cost in **time** by preventing broken springs and vibration and jar to the car (see page 26). The **greatest** shock when going over rough places **on** the road is during the rebound. The shock **absorber** absorbs this rebound motion and **also** prevents broken springs. See index "shock absorber."

A mirror on windshield so placed that the driver can see behind him, is another desirable accessory, as is also a mechanical tire pump. An electric hand lamp with several feet of lamp cord—for exploring around the engine or car—which attaches to the dash light socket by removing the bulb, is also very handy.

A tonneau windshield as per fig. 6, page 514 might be termed a necessary accessory.

Lack of space prohibits the enumerating of other desirable accessories both wise and otherwise.

Signal Alarms.

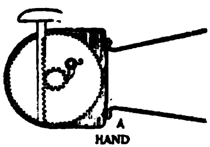
There are a variety of devices properly designated as signal alarms including: bells, bulb horns, electric horns, exhaust whistles, compression whistles, etc.

In the early days the mechanical electric bell, operated by the foot, was the applied method for warning the pedestrian—possibly this was not necessary as the cars in those days made sufficient noise to warn a block ahead.

Then came the bulb horn, but the old style bulb horn has about seen its days. It is seldom used, because of its difficult method of bulb operation and getting out of adjustment at the reed.

The compression whistle is the type shown in fig. 4, chart 222. It is desirable where there is no battery or where the battery is not of sufficient size to operate an electric horn. This type of alarm is very popular and saves battery current.

The exhaust horn or whistle was used extensively at one time, but is now seldom used.



The hand operated horn, as per fig. 4, is not desirable for two reasons: one is as per above and the second it is operated by hand at an inconvenient place. It is too near driver, whereas it ought to be nearer the front of car. When side curtains are down the result is, the noise is thrown inside of car instead of outside.

The vibrating type of electric horn is similar to a vibrator on an electric bell. Instead of the clapper striking a bell, it strikes against an adjustable rod, which is connected to a diaphragm (D), as explained in fig. 7, chart 222.

†**The motor type of electric horn** consists of an electric motor of small size with its armature and winding (M). On the end of the armature shaft a case hardened steel rachet wheel (W) (see figs. 5 and 6) strikes against a hardened steel button (B) on the diagram (D). The motor horn is the more desirable.

Construction of the electric motor horn; there are two types. The **vibrator** type of horn as shown in fig. 7, chart 222, and the **motor** type, figs. 1, 2, 3, 5 and 6; fig. 4 is a hand operated type.

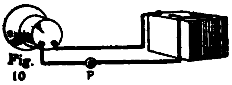


Fig. 10

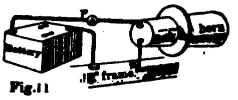


Fig. 11

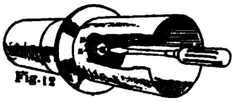


Fig. 12

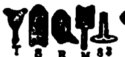


Fig. 13

Fig. 14

Wiring on electric horn can be either "two-wires," fig. 10, or "grounded" return, fig. 11.

Fitting the electric horn to a car; a horn ought to be placed on the opposite side from driver and far away, in front of car if possible. The reason is, the noise is then away from occupants of car and the signal is placed where it is most effective, usually under the hood, to the front.

Adjusting a Stewart electric horn, fig. 12, is very simple. Always lock screw (3) with nut (N) after adjusting.

Horn brackets fig. 13 are for automobile use and are arranged so that horn can be mounted at different angles. M and 83 are for motor boat use. American Electric Co., Chicago, supply brackets.

Handles for hand actuated horns (fig. 14) can be had of some of the horn manufacturers,—suitable for long continued blasts when used on boats.

*A Transcontinental Tour—The Lincoln Highway.

The transcontinental tour is now comparatively easy and decidedly worth while to anyone who can possibly arrange to take it. I say "now," because such has not been the case in the past. Until very recently, a trip across the continent has been more or less of an adventure, a somewhat hazardous as well as an expensive and lengthy undertaking, requiring some measure of endurance.

Frank Trego in writing an article for Motor Age gives some very interesting data on touring. This article,—a part of which we give—was printed in Motor Age, and is reproduced on following pages.

---

*For a shorter tour, the reader can go over the lists on pages 517 to 520 and select what he thinks will be required.

**Lamp lens which are not glaring are necessary in most States. †See page 418 testing electric horn.

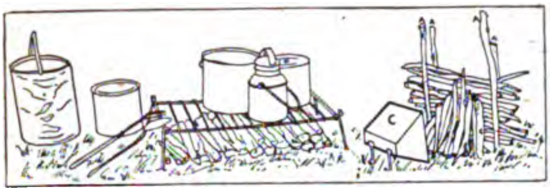


FIG.5 COOKING FIRE FIG 6 BAKING FIRE

Fig. 5—Explains the method of making a cooking fire as described in Mr. Trego's instructions on pages 519 and 520, note the iron rods (B) and iron frame with cross rods.

Fig. 6—Explains the method for building a baking fire which must be high. Note the sticks (A) are of green material whereas the burning material is dry. C is the patented baker, made of aluminum.

Fig. 22.—The Auto-Kot Co. manufacture a very serviceable and compact adjustable cot which can be placed on the top of rear seat, and front seat of a 5 or 7 passenger car. It can be folded in a very compact form and placed back of the front seats. (Peoria Auto-Kot Co., Peoria, Illinois.)

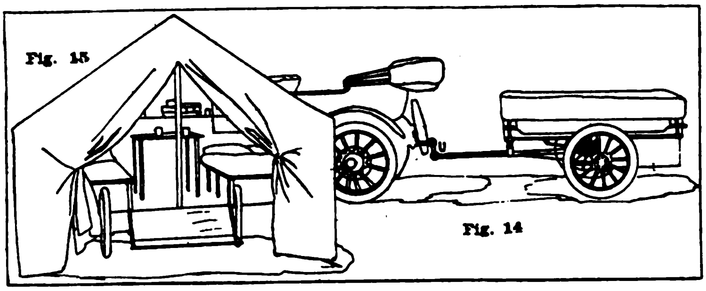


Fig. 15

Fig. 14

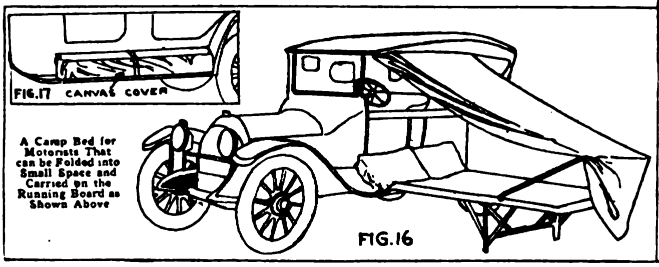


FIG.17

A Camp Bed for Motorists That can be Folded into Small Space and Carried on the Running Board as Shown Above

FIG.16

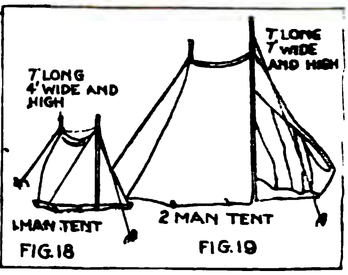


FIG.18 FIG.19

Fig. 14—Pictures a new idea of camping. A trailer (fig. 14) is carried with you and it is stated it will travel 50 miles per hour along with car. The tent and all parts are placed into this trailer.

Fig. 15—Shows the tent when removed from trailer and trailer used as the floor, and tail gate of trailer is utilized for a step. This outfit is made by the Auto-Kamp Equipment Co., Saginaw, Mich.

Fig. 16 shows another principle. Note the compact form of the outfit (fig. 17) when placed in box on running board and covered with canvas.

Fig. 18—Explains Mr. Trego's method for erecting tent as explained on page 517. The one man and two man tent is shown. Note the bottom of tent itself is used to hold the sides. This tent made of balloon silk can be swung between two trees or poles.

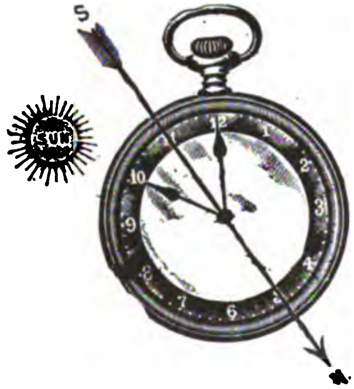


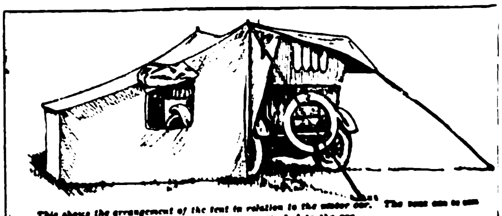
Fig. 20.—To use your watch as a compass: Point the hour hand of your watch to the sun at any time of the day, then lay the watch flat in your hand. A point midway between hour hand and 12 on dial will be due South.

Another outfit shown below: The tent has a floor 8 feet square which is sewed in. An extension of about 2 feet on the front edge of the floor can be fastened over the running board of the car. The front wall of the tent is 7 feet high and extends over the top of the car when the tent is pitched in this way, or it may be used as a straightfront for the closed tent when the car is not attached.

Two 7-foot poles prevent undue strain on the car top. The poles were cut with slip joints to be of proper 4-foot length to carry on the running board. The side walls have extensions of about 10 inches on the front edges to fasten to convenient places about the car, making a tightly closed tent in case of storm or cold wind. One side wall has a window, and the other has a door.

The rear wall is about 3½ feet high and was kept at a convenient height by its location near a fence, tree or other object to which ropes could be attached.

The tent was made of khaki at a cost of $18. Folding camp cots were used . The use of heavy blankets on the tent floor during cool weather was preferred to the cots. The tent was adapted to an Overland by a 6 inch flap sewed to the front wall to make sure of protection for the car. The size given is suitable for a car having a 7½ or 8-ft. top.



This shows the arrangement of the tent in relation to the motor car. The tent can be used also without being attached to the car

CHART NO. 223—Camping Outfit. Camping Tents. How to Build a Fire. Watch as a Compass

continued from page 515.

One can drive for nearly 2,000 miles across the antry without once being more than half a ile from the familiar red, white and blue Lin-ln Highway markers.

The only thing which might make a coast-to-ast automobile trip a hardship, would be a lack proper equipment and perhaps the wrong time year.

The greatest asset on a trip of this kind is common sense." The next greatest asset is efficient equipment."

The time required for the trip, with easy drivag, will be nineteen days, driving approximately n hours per day. This will make an average of pproximately eighteen miles per hour, during the riving time.

Dress: White collars and cuffs are impossible n camp and soiled linen looks a thousand times vorse than a flannel shirt. The khaki and flanel are much more welcome in a hotel.

Make ready before starting—not after. Fit vourself as well as your car.

The tent: If a one person affair where two sleep together—a balloon silk tent, 7x7x7 feet, A-shaped with water proof canvas floor sewed in, and loops along the ridge to tie rope when stretched between trees or in using poles. (See fig. 19, chart 228.)

The one person tent, (fig. 18,) called the Trego tent can be A-shaped, 7 feet long, 4 feet high by 4 feet wide, with a ridge rope sewed on and extending about 10 feet beyond each end. Floor, water proof canvas sewed into the sidewalls which hang over slightly.

At the head end is a little window covered with mosquito netting sewed in, and outside of this is a curtain which may be raised and lowered at will from the inside of the tent. At the foot are two flaps, overlapping each other when closed, and equipped with snaps and rings for fastening either open or closed. Sleep with the flaps and window of your tent open unless it is storming. A rope loop is attached to each corner for stakes; but, as a rule, the stakes will not be necessary, as the bedding holds down the floor.

This tent may be slung between two trees. If not used in this manner, the ropes at each end should be led over 4-foot stakes of some kind and the corners of the tent must then be staked down, so that the walls will act as cross pieces to keep the end poles upright.

This size tent will take blankets folded once over, and all of the extra clothing, etc. can go under the blankets at head and serve as a pillow.

The blankets are to be pinned across the foot of the head end, with horse blanket safety pins, procurable at any harness store, spacing them about 8 inches apart. There should be 2 pair of heavy blankets and one cheap cotton quilt. Fold this last mentioned over once and place under blankets to serve as a mattress.

Always keep a small whisk broom handy.

Sleep with clothes on, unless weather is warm, simply remove your shoes, leggings (use only canvas leggings, not leather), hat and handkerchief.

Camp location. Pitch where natural drainage will carry water off in case of rain. In the forest, cut a lot of small pine branches, no thicker than your finger, and rip-rap these with the stems to the foot, making a pad the full width of your tent, and about a foot thick, before you lie upon it. If there are no trees to furnish this, dig a trench about 3 inches deep by 8 inches wide just where your hip will come when you lie upon your side. This will add wonderfully to your comfort.

It makes no difference how the tent is placed, except do not get the foot or open end toward the wind.

Protection from the wind; try to get the camp out of the wind, on account of cooking. Along side of the woods is much better than in them, on account of the mosquitoes, flies, bugs, etc.

Get near running water, if possible, although by carrying a 5 gallon milk can on running board you are independent.

Drinking water: Should be selected and carried in a 5 gallon milk can which can have a wood circle placed on running board to hold in place and straps made on the order of a harness over same. Don't be dependent upon other water—keep a supply on hand.

***When stuck in mud:** If the rear wheels are stuck in the mud, dig holes in front of the front wheels for them to fall into to give the initial start, and, if the car does not continue, then block the rear wheels instantly and repeat the operation. Place brush in front of the rear wheels and turn them as slowly as possible to keep from churning. If one rear wheel is on good road, try putting on the handbrake fairly tightly to destroy the action of the differential, or fasten the mired wheel so that it cannot turn, and the other wheel will do the work and slide the mired wheel along the ground.

The instant you realize you are getting stuck in sand or mud, stop right there and look over the situation, instead of fighting the car and burying it deeper and deeper.

Start early and stop before dark to select the camp site.

Use the windshield up to keep the hot, dry air from burning your face, and have the top up all of the time for like protection.

Get all of your guide books before you start.

In asking directions, always apply to a garage or livery stable, but do not depend upon farmers, as their knowledge of the road does not extend very far.

If a party of four, let one do the cooking another gather fire wood, another put up the tents, and the fourth go over the car with oil can and turn up all grease cups, adjust brakes, etc.

The Car Kitchen.

This outfit is designed for four people and weighs about 10 pounds. All items marked A-V may be purchased at Von Lengerke & Antoine, Chicago, or Abercrombie & Fitch Co., New York, and the unmarked items may be obtained at almost any store dealing in such goods.

A-V 1 Arizona camp grate, 24 by 12 ins.	$0.85
A-V 1 set pot hooks	.25
A-V 1 Aluminum folding baker, 8 by 18 ins.	8.50
A-V 1 Canvas case for above baker	1.50

The following Armorsteel pieces of cooking outfit may all be purchased at A-V. Prices of totals given:

1 Frying pan, 9⅜ inches wide, with patent handle	.55
1 Cooking pot, 9⅝ inches wide	.85
1 Cooking pot, 8⅛ inches wide	.75
1 Cooking pot, 7¼ inches wide	.65
1 Coffee pot 6⅝ inches wide	1.00
4 Soup bowls, 4⅝ inches wide	.32
5 Cups 4 inches wide	.40

Don't use aluminum cups.

6 Plates, 8¾ inches wide	.30
4 Forks, with four prongs, 7¼ ins. long	.12
4 Knives, 8¾ inches long	.40
6 Teaspoons	.12
2 Cooking spoons	.20
1 Carving knife, 10¼ inches long	.15
1 Sharpening stone	.25
1 Set tin lids for the pots and frying pan	
1 Pancake turner, 8 by 4½ inches	.05
1 8-prong cooking fork	
A-V 1 Collapsible wash basin, 12 by 3 ins.	.50
1 Camper's carbide lamp Abercrombie & Fitch Co. No. 3A937. Be careful to read the instructions.	1.50
A-V 1 lb. Carbide for above lamp	.10
A-V 2 Canvas duffle bags, 10 by 24 inches (use for food only)	2.00
A-V 1 doz. Food bags, 9 by 9 inches	1.20
A-V 2 Food bags, 9 by 14 inches	.30
1 Agateware milk can with tight lid—2-quart. Use for the stewed fruit only.	
2 Patent egg carriers.	
1 Tin bread pan, 10 by 4 inches. Use also for washing dishes	.10

---

*Pull-U-Out Sales Co., 2024 Market St., St. Louis, Mo., manufacture a device suitable for this purpose. see index.

1 Inspirator, for camp fire—(2 feet small rubber hose, one end of which is slipped over one end of a 3-inch piece of copper tubing and the other end of this tubing is flattened to make a slit about 1/32-inch opening). This is a wonderfully handy thing for getting a balky fire going.

Car Equipment:

This equipment is suitable for a transcontinental trip or for a shorter one:

2 Extra tires mounted on demountable rims.
2 Extra tires with tubes, covers on them.
4 Extra tubes in bags, under rear seat.
5 Gallons good water.
*60 Feet 5/16-inch flexible steel cable.
1 Medium size shovel, strapped to running board.
2 Gallons engine oil, in 1-gallon cans. Under front seat.
1 Set weed chains, heavy type.
6 Extra cross chains.
1 Set spring chain tighteners.
1 Set regular tools for car.
1 Car jack.
1 Pair good cutting plyers.
1 Piece hardwood 1½ inches by 4 feet by 10 inches.
1 2-quart canteen. Buy west of Missouri river.
1 Blow-out patch for casing.
3 Extra spark plugs.
8 Feet high-tension wire.
8 Feet low-tension wire.
1 Extra valve and spring complete.
1 Medium-sized axe. Strap to running board.
1 Small can Le Page's glue, for mending camera, etc.
1 Hose upper radiator connection
1 Hose, lower radiator connection.
1 Canvas folding bucket for water; 9 by 12 inches.
1 Can cup grease. Under front seat, and so packed that it cannot upset when melted.
1 Set extra electric lamp bulbs.
1 Set extra fuses for electrical system.
2 Packages small, cheap towels, for wiping machinery, etc.; one dozen in each package.
150 Feet ¼-inch best Manila rope, for packing, etc.

Personal Equipment:

When on a camping motor trip, the first thing of importance is common sense. The second is proper equipment.

Now for the list. This is the minimum for a long trip, and of course, may be added to according to the tastes and ideas of the individual, but more is entirely unnecessary and should be avoided, if possible.

1 Pair tan shoes, light-weight. Don't wear new shoes.
3- Pairs light cotton lisle socks.
A-V 1 Pair canvas puttees, light-weight. Don't wear leather . ... $ 1.00
A-V 2 Pairs kahki riding breeches, laced below the knee. Don't wear corduroy. Each 3.50
2 Pairs light wool drawers.
2 Light-weight wool shirts to match above
2 Pairs B. V. D. under suits.
A-V 2 U. S. Army officers' brown shirts. with patched pockets. These are twice as warm as $2.50 flannel shirts, and are practically wind-proof. Each 4.50
A-V 1 Light-weight kahki coat. To wear in towns 2.00
A-V 1 Heavy mackinaw coat with shawl collar. For driving when it is cold at high altitude and by the camp fire.. 13.00
1 Pair light-weight gauntlets, for driving.. 2.50
1 Pair old street gloves, for wear around camp.
A-V 1 Kahki hat with narrow brim. Cut ½-inch ventilating holes on each side.. 1.50
2 Blue and white bandanna handkerchiefs. Tie up snug to your neck and don't wear loose like the pictures of cowboys. Each . ... .15
6 Pocket handerchiefs.
A-V 1 Pair light-weight moccasins. For wear around camp and to sleep in.... 2.00
1 Toothbrush.
1 Hair comb.
1 Pocket knife, three blades and strong.
A-V I Pocket compass 2.00
1 Safety razor and two extra blades.
1 Can shaving powder.
1 Shaving brush.
1 Mirror, small.
1 Ingersoll watch, with fob.
1 Pair yellow goggles. Don't forget these.
1 Pair white goggles.
1 Tube tooth paste.
1 Package bachelor buttons.
1 Pair scissors, small.
1 Set Needles and thread.
1 Pair manicure scissors. Don't forget these. Hangnails are a great source of trouble on long trips.
1 Narrow leather belt.
1 Stick camphor ice. Much better than any form of cold cream and very handy in package. Use it only at night unless riding in the shade of the top, as the hot sun will blister the lips on account of the beads of moisture acting as lenses on the lips after using the camphor ice.
2 Dozen cathartic tablets.
1 Package gauze.
3 Rolls gauze bandages, 2 inches wide.
1 Tube vaseline, for burns, guns, etc.
A-V 2 Pairs 5-lb. wool double blankets,
1 Cotton quilt.
1 Tent. Trego sleeping tent. Purchase at Von Lengerke & Antoine, Chicago.
1 Camera.
12 Rolls film for camera.
1 Welcome photographic exposure record. This is a red book bought at any photo supply store . ... .50
1 Small whisk broom, for use in tent, etc.
1 Silk sleeping cap, to pull down over the ears.
2 Coarse towels.
2 Pipes, if you are a smoker, and plenty of your favorite tobacco.

What to Cook and How.

Bacon: This is the standby of all camping parties and is really the best meat to carry, as it keeps well and is easy to cook. It should be placed on bread and eaten as a sandwich, thus you will not miss butter. Fresh meat should be attempted only by the expert cook. There is a science in cooking bacon, and but few people seem to catch the idea. I will try to make it as clear as possible.

In the first place, do not buy the sliced bacon under any circumsances. Buy the bacon in the slab, as lean as possible, and of the very best quality. Buy one full slab at a time as you go along and cut this into three pieces to go into one of the larger food bags. Now, when slicing the bacon before each meal, cut the slices at least 3/16 to ¼-inch thick. Bacon, which is sliced thin, cannot possibly be fried properly, as it will curl up in spite of you and burn one end while the other end is raw.

Cutting the bacon: After cutting the slices down to the rind, cut this off by passing the knife under the slices horizontally, with the slab lying flat. Lay the slices in the *frying* pan, putting in as many as may be required, regardless of whether they rest on top of each other or not. Set the pan on the grate and, after the grease begins to form, tilt the pan this way and that so that the grease flows all through the slices. Watch it carefully and turn the slices frequently with your fork. In the meantime, have a plate warming on one corner of the grate, and as the slices become fairly brown on both sides, pick them out with the fork and pile them up as closely as possible on this plate. As soon as all are done, cover the plate with another and set where it will be kept warm. This will keep the slices moist with the heat and grease left in them and they will not become brittle and dry. The remaining grease in the pan can now be poured into one of the cups for future use, or that meal, for frying eggs, etc. Eggs fried with bacon grease have a fine flavor.

It is astonishing how few cooks know how to cook rice so that the grains will be soft and et stand apart. Boiled rice is a great dish or camp, if properly cooked, but is miserable tuff if cooked into a thick paste.

---

*A good auto tow line (flexible wire) is manufactured by A. Leschen & Sons Rope Co., St. Louis. It is called "Hercules Wire Rope Towing Line" and is 25 ft. long between end fittings.

Take next to the largest pot and fill it about hree-quarters full of cold water and add about one-half teaspoon of salt, then put in three-quarter cup of rice and put on the lid, placing the pot over the fire on the grate where it will get a good heat to boil. The rice should boil for about 30 minutes, and if desired, it may be tested by gathering a little in the spoon and chewing it, to see that the grains are soft. Stir frequently and scrape the bottom of the pot with the spoon.

After the rice is done, take the pot to one side of the camp and pour off all the water you can by holding the lid in place and turning the pot almost up-side-down. Now set it to one side with the lid on until needed, and the rice will steam so that the grains will stand apart. You will find this a delicious dish, which should be served with evaporated milk and sugar, or with a sauce of fruit juice. Cook a fresh lot for each time served and do not try to save it for the next meal. If you have too much rice for the quantity of water it will produce a mixture like glue, and is poor stuff to eat.

Fifteen-minute bread: Most campers will shy at making bread, but really it is very simple and is made in about 15 minutes. The patent baker is a marvel and will brown the loaf equally on top and bottom, no matter how the wind blows. A special kind of fire is required to bake bread, so do not attempt it at the regular cooking fire.

To build the correct fire, drive two stakes in the ground about 2 inches apart and 2 feet from there drive in 2 more likewise. Between the vertical stakes, lay a wall of sticks about 1 to 1½-inch thick, perferably green sticks, and against this wall set a lot of fire stuff which will burn rapidly and make a high flame with little smoke. You must have a high flame. This should be kept going brightly until the bread is done. (See fig. 6, chart 223.)

Test the bread by piercing the loaf with a sliver of wood. If no dough sticks to the sliver, then the bread is done. Of course, it should be fairly brown on top before testing. Leave the pan in the baker and remove from the fire, setting to one side where it will receive a little heat from the regular fire to keep warm. The aluminum baker will retain the heat for quite a while.

Carry whole wheat flour only, and in the larger food bag. Of this take one and one-half cups and put it into the bread pan for mixing. Add to this one and one-half heaping teaspoonsful of baking powder, one level teaspoon of salt, three teaspoons of sugar and one and one-half cups of water. Stir gently until thoroughly mixed, but do not beat. Warm the baking pan and then grease it all over the bottom and around the sides and corners with a strip of bacon rind, then pour in the batter you have made and place the pan in the patent baker. Set this before the baking fire quite close, say one to two feet. It will begin to rise immediately and will bake into a loaf about one to one-half inches thick, which will be just right for four hungry people. This bread is great, and will stick to your ribs on the long hike. It is so much better than baker's bread and very little trouble after you once get the hang of it.

Dessert a la tour: You will find that stewed fruit is far ahead of the canned goods and much better food. In the food list you will notice that peaches, prunes and apricots are specified, dried. These will be all mixed together and used that way. The flavor is much better than when used separately.

Fill your 2-quart milk can about one-third full of this dried fruit and then fill up with cold water, adding three tablespoons of sugar the day before you start, and then at the first night stop, place the can on the grate over the fire and allow to simmer, first loosening up the lid to let the steam escape. After serving the fruit, you can put in more fruit, add more water and sugar and carry it with you to the next stop, repeating the simmering process. In this manner the mixture will become quite syrupy and of fine flavor. About every 3 days empty the can and wash out with hot water, beginning over again as you did in the first place.

The breakfast drink: Use 8 teaspoons of ground coffee to one cup of cold water in the coffee pot. Set on the fire until it comes to a boil, then pour one-half cup of cold water over the top, going round and round, and a little down the spout. Set the pot aside until served and then pour carefully and slowly, and the coffee will be clear.

No egg or anything of that sort is needed to make clear coffee. If the coffee food bag is tied tightly, it will keep in the ground state all right, so do not carry it in the can in which it is sold.

Tea: If tea is used immediately, pour boiling water over the tea leaves and let stand for a few moments only. If it stands very long with the leaves in the pot, it will make a mixture which will absolutely tan the lining of your stomach. If the tea is to be kept for any length of time, put the tea leaves in a piece of cheese cloth and tie with a bit of string, fishing this out of the pot after the tea has soaked for a moment in the boiling water. Shake out the cloth and put away for the next time. If the cloth is used, you can save the tea for a long time and serve cold, if desired. This is often handy for the late hunter in camp, if side hunting trips are made away from the car.

The army ration: Erbswurst, (pea sausage in English) powered pea meal and bacon. This is a very palatable and nourishing food, and is used extensively as the perfect army food by the nations of Europe. It is sold in round packages about 1 inch in diameter and 4 inches long, and each package is marked in 6 divisions, one of which is to be used for each cup of water. Boil for 20 minutes. It is already seasoned.

Pan cakes are very nice for a change and should be served with maple syrup, as one craves sweets when living out of doors. Buy the syrup in small cans. For the cakes, buy self-rising buckwheat flour and mix with cold water, with possibly an egg added for richness, until the batter is quite thin and will run readily from the spoon. Rub the frying pan with grass or a rag thoroughly to smooth its surface, then grease with a strip of bacon rind and pour in a large spoonful of batter at a time, while the plan is piping hot. The pan will hold 3 cakes of this size at a time. Cut them apart with the pancake turner as soon as you can and loosen them from the frying pan by slipping the turner under the cake without lifting it. As soon as you can handle them on the turner, flop them over to brown on the other side. . If the batter is not thin enough, the cakes will be tough and heavy.

Potatoes are really a necessary article of food on a long trip lasting several weeks, and should be served about once each day, if convenient. Peel the potatoes and then boil them in the largest pot for about 20 minutes, if you are going to fry them, and 40 minutes if they are to be served boiled only.

In high altitude, the boiling process will require much longer, as the water boils at lower temperature. "All that bubbles does not boil" in the high mountains.

To fry the potatoes, first boil them as above directed and then cut into slices about ¼-inch thick. Pour about 1/16 inch of the bacon grease into the frying pan, covering it evenly. Heat this on the fire until it sizzles and put in the potatoes. Take a knife and immediately chop the potatoes into small pieces and put on the cover. Stir and turn over frequently with the knife and test them for softness with its point. When nice and soft they are ready to serve and the bacon grease will give them the desired browning. The bacon grease has a much better flavor than lard.

Canned Goods: These are good for a change, where they can be conveniently carried, but are not at all necessary. In all cases of vegetables and soups, simply pour the contents of the can into one of your pots and heat it over the fire Do not forget to stir it to keep the mixture from sticking to the bottom of the pot

Water: Be very careful of the water you drink, especially west of the Missouri river. If there is a white deposit around the edge of the lake or pond from which you wish to get the water, it is alkaline and will make you very sick. Fill your big milk can with good water in the towns and then drink that instead of taking a chance on water found by the roadside. Animals can drink alkali water without harm, whereas it would seriously affect a human being.

This 5-gallon supply of water will be used for all purposes, as it will be required only for the radiator in case of accident. Fill the radiator when you fill the gasoline tank and you will have all you need.

Cooking fire: This fire is to be built under the grate the four legs of which have been driven into the ground until the grate is about 8 inches high. Build this fire of small sticks, from the size of your finger to 1-inch diameter. No larger. Have this fire at some distance from the cars and from the main camp fire and on the lee side of both. The sticks should not be over 14 inches long. The smaller the fire, the better to keep the heat down, so that the cook is not roasted as well as the food. You may build the fire the full length of the grate if you wish, but keep it down. Do not attempt to cook at the camp fire, for the smoke and heat will make it a martyr's job. Fig. 5 shows the proper method.

A baking fire: Build this away from the other two as shown in fig. 6.

Camp fire: Do not build this near the cars and be sure to have it on the lee side of them on account of possible sparks. Build a moderate-sized fire only, so that you can gather closely around it and converse easily. "Injun build little fire and sit up close—white man build big fire and sit away off." Build yours the Indian style.

Be sure to put out all fires with your shovel before breaking camp. The western forestry laws are very strict about this.

Packing: Packing the outfit on the car is quite important and it should be standarized at the start and then everything always should go back in the same place. Much time may be saved if this is carried out as all of the party become familiar with the location of each item and the car will be loaded in an astonishingly short time.

Method of stowing is as follows:

Cooking Grate—Under floor mat in tonneau.

Large water can—Right running board forward.

Extra tires not on rims—Left running board forward.

2 tent beds—On end, each side of back of front seat. Tie to robe rail.

Cooking utensils—Between these beds in tonneau.

1 tent bed—Right running board. Strapped on.
1 tent bed—Left running board. Strapped on.
Shovel—Left running board behind tires.
Axe—Tonneau floor just back of beds.
Food bag—Tonneau floor. Passengers can rest feet on it.

Patent baker—Hanging where it will not be crushed.

The cooking utensils all go into a canvas bag which is sold with them and the outfit is very compact.

Food List:

2 Slabs best bacon—lean.
5 Pounds whole wheat flour.
5 Pounds sugar.
1 Pound salt.
2 Pounds best baking powder.
2 Cans maple syrup, small cans.
1 Can pepper, small.
8 Pounds ground coffee.
12 Cans evaporated milk, unsweetened.
1 Roll surgeon's plaster 1 inch wide—for sealing cans, etc
5 Pounds dried fruit—apricots, peaches, prunes in equal portions.
1 Pound tea.
1 Can cocoa.
1 Pound self-rising buckwheat flour.
8 Pounds rice.
2 Cans tomatoes.
2 Cans corn.
2 Boxes graham crackers.
4 Quarts potatoes.
12 Packages Erbswurst.
2 Dozen eggs in patent carriers.
2 Boxes bouillon cubes.

Some of the Concerns who Make Camping Equipments.

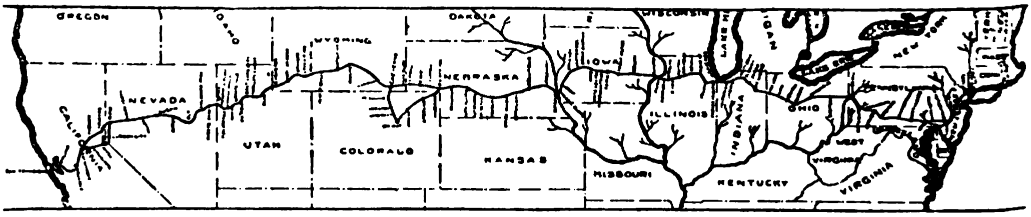
Marshall-Field Co., Chicago, camping refrigerators, lunch equipment, tents and complete camping outfits.

Cozy Camp and Auto Trailer Co., Indianapolis, Indiana.

Auto-Kamp Equipment Co., Saginaw, Mich.

Ideal Mfg. Co., North Kansas City, Mo., folding shovel.

Peoria Auto Kot Co., Peoria Ill.



Route of the Lincoln Highway. Further information can be had by writing Lincoln Highway Association, Detroit.

The Official Automobile Blue Book, a Road Guide.

Assists in planning a tour and gives detail running directions.

Vol. No. 1. New York and Adjacent Canada.

Vol. No. 2. New England and Maritime Provinces.

Vol. No. 3. New Jersey, Pennsylvania, Delaware, Maryland, District of Columbia and W. Virginia.

Vol. No. 4. Lower Mich., Ind., Ohio and Ky.

Vol. No. 5. Ill., Minn., Wis., Iowa and Mo. and upper Michigan.

Vol. No. 6. The Southeastern States.

Vol. No. 7. Mont., Wyo., Colo., N. Mex. Texas, N. and S. Dak., Nebr., Kans., Okla., Ark. La.

Vol. No. 8. Calif., Utah, Nev., Ariz.

Vol. A. New York City Metropolitan Blue Book.

Vol. No. 9. Wash., Oreg., Idaho, British Col.

The price of each volume is $3.00. The address of publishers are The Automobile Blue Book Publishing Co., 243 W. 39th St., New Lork. 910 S. Michigan Ave., Chicago. 513 Pacific Bldg. San Francisco, California.

A very large space in which to carry needed articles on a tour is to provide a long box, width of running board and cover with black rubber carriage top cloth. This will make a good dust and rain proof receptacle in which to carry clothing, lunch boxes, etc.

INSTRUCTION No. 38.

INSURANCE, LICENSE AND LAWS: Kinds of Insurance. Automobile Registration Fees. Chauffeurs' License. Laws of Different States. Some of the Questions Asked by Some of the State Board of Examiners. SELECTING A CAR; buying a new car; judging a second-hand car; buying a commercial car.

*Insurance.

Fire insurance is very essential to the operation of an automobile, on account of the exposure it is subjected to, both on the street and in the garage, and most owners carry fire and theft policies.

Liability insurance is also a very important asset, and owners should be very careful about their selection of a company to carry their risk. The company should necessarily be one with large assets, and of sufficient financial strength to protect the policy holder through years of action in the courts, because in some cases; especially where serious injury is involved regardless of the cause or blame for the accident, years have elapsed before settlement is agreed upon, or final judgment is rendered.

Kinds of Insurance.

There are five classes of automobile insurance, as follows:

(1) Fire and theft.
(2) Liability.
(3) Property damage.
(4) Collision.
(5) Loss of use.

Fire and theft can be combined in one policy, or fire insurance can be written separate excluding theft; but the theft feature cannot be written unless accompanied by the fire insurance. Collision can also be included in the fire only, or the fire and theft policy, but it like the theft insurance cannot be written separately. Liability and property damage is usually written in a separate policy, although several companies are writing a joint "all risks" policy covering fire, theft, liability, property damage and collision. This can be done by re-insurance between the liability and the fire companies.

(1) The standard automobile fire and theft policy covers the body, machinery and equipment of the car. Extra bodies, robes, automobile coats, hats, caps, gloves, leggings, boots, goggles and chauffeur's livery are not included unless provided for under a separate endorsement, for which additional premium is charged in accordance with the amount of coverage desired. Automobile fire insurance is written in two forms; one covers fire and theft, and is known as a "valued policy" on account of the company being liable for the amount stated in the policy at the time of a loss; the other provides that the company may deduct a reasonable amount from the loss for depreciation however caused. A credit in the rate is given for the latter form of coverage which is known as the "non-valued form." A credit of 15 per cent is granted from the fire rate where an approved chemical fire extinguisher is attached to the automobile.

Theft insurance as stated above can only be written in connection with a fire policy, and the same conditions regarding "valued" and "non-valued" clauses apply. On all cars listing under $2000.00 the companies require the attachment of an approved locking device for which a credit of 15% is granted from the theft rate. Where no lock is provided an additional charge of $15.00 is made.

(2) Liability insurance provides protection against accidents to the public resulting in injury or death. The usual limits of liability are $5,000.00 for an accident resulting in an injury to one person and $10,000 for an accident resulting in injury to more than one person. The purpose of this insurance is to pay judgments, costs of court, attorney fees, witness fees, investigation and settlement costs, and other expense necessary to the protection of the automobilist, not exceeding however, the limits above stated. These limits may be increased where necessary by payment of additional premium.

(3) Property damage insurance covers damage to the property of others, not exceeding one thousand dollars.

(4) Collision Insurance covers loss or damage to your car caused by a collision with another object. There are three classes of collision insurance; one known as the ($50.00 deductable form), provides that the company will deduct $50.00 from each claim; another known as the ($100.00 deductable form), provides that the company will deduct $100.00 from each claim, and still another known as the (full coverage form), which provides that the company will pay all claims in any amount. The insurable value on collision insurance is based upon the same principle as fire insurance, a fixed percentage of the list price of the car being granted in accordance with the age, use, physical condition, etc.

(5) Loss of use: This form of coverage has just recently been included, and applies in connection with the property damage insurance, providing reimbursement to the owner on account of sums he may be called upon to pay to others through the loss of the vehicle which has been damaged; i. e.: cost of rental of another vehicle pending repairs to the one damaged, not exceeding one thousand dollars.

Rates.

Insurance rates vary in different parts of the country, therefore it is advisable to see your local insurance agent.

---

*Above prepared by E. F. Decker Ins. Co., St. Louis.

* AUTOMOBILE LICENSE OF DIFFERENT STATES; the cost and how to secure a license.

There are two kinds of license issued for automobiles; one to the owner of the car which covers a tax or fee on a car as well as the privilege of the owner to drive the car. The other, is a license issued to a professional chauffeur.

Some states do not require chauffeurs' license. Other states require the chauffeur to obtain a license which is usually done by writing to the secretary of the state at the capitol city for a form to fill out, which, when filled in and the amount of license remitted, he is then supplied with a badge and receipt. Other states require an examination. The table below gives the name of the states requiring the above and where to send for the license.

The information, even though you do not purchase a license can be obtained by writing to the secretary of your state. Inasmuch as the laws are sometimes amended or changed, it would be well for the reader to write for the information, which will be supplied to him gratis.

The age of driver of an automobile must not be less than 18 years, in all states except California (16), Colorado (15), Nebraska (16), New Hampshire (16), New Mexico (14), New Jersey (16), Ohio (16), Pennsylvania (16), Rhode Island (16), Wyoming (15), Delaware (16). Some of the other states do not set an age limit.

State.	Registration.				Licenses.				Non-Resid'ts.	Speed Regulation.
	Where to Apply.	Fees.	Duration.	Renewal.	Requirements.	Fees.	Duration.	Renewal.		
ALABAMA	Sec. of State, Montgomery	Less than 20 h. p., $7.50; under 30, $12.50; under 40, $17.50; 40 h. p. or more, $30; trade, $100 per garage, dealers, $125, rented cars, $25.	Annual	October 1st.	No examination.	Chauffeur's licence, $5, original; $2.50, renewal.	Annual.	Oct. 1st.	Exempt (reciprocity).	Prima facie evidence of excess; 30 miles per hour ¼ of a mile.
ARIZONA	Sec. of State, Phoenix.	23 h. p. and less, $5; 23-40, $10; over 40, $15; manufacturers and dealers, one registration; 50c. for each additional seal.	Annual	January 1st.	None.	Chauffeur's license, $5.	Perpetual.	None.	Exempt, 6 months.	Closely built up, 10 m.; elsewhere in city or town, 15 m.; open country, 20 m.
ARKANSAS	Sheriff of County	$10. Manufacturers and dealers one $10 license for each class of car.	Annual	January 1st.	No examination.	Chauffeur's license only, $1.	Annual from date of filing.	——	Exempt.	Prima facie evidence excess; cities, towns, 15 m. for ¼ m.; open country, 20 m. for ¼ m.
CALIFORNIA	Motor Vehicle Division, Sacramento.	$2.00. Manufacturers and dealers; $2.00 for each class of machine, 50c. for each additional tag.	Annual	January 1st.	No examination.	Chauffeur's license only, $2.	Annual from date of issue.	Expiration.	Exempt 3 months in calendar year.	Cities, 15 m., open country, 20 m.
COLORADO	Sec. of State, Denver	Up to 20 h. p., $2.50; 21-40, $5; 41 up, $10. Trade, $5, five cars.	Annual	January 1st.	No examination.	Chauffeurs, $1.	Annual.	Jan. 1st.	Exempt 90 days.	No general speed limits.
CONNECTICUT	Sec. of State, Hartford.	50c. per h. p. Manufacturers, $1.00 each, not less than 25 machine. Dealers, $50.00.	Annual	January 1st.	No examination.	All operators, $2.	Annual.	Mar. 1st.	Exempt.	Prima facie evidence of excess; 25 m. for ¼ m.
DELAWARE	Sec. of State, Dover.	$3. Trade, $5.00 each car with same number	Annual	January 1st.	No examination.	All operators, $5; family $4.	Annual.	Jan. 1st.	Exempt (reciprocity).	Cities and towns, 12 m.; open country, 20 m.
DISTRICT OF COLUMBIA	Automobile Board, Washington.	$2. Fees paid to Collector of Taxes, Washington.	Perpetual.	——	Examination. Operator's permit.	All operators, $2.	Perpetual for one car and owner.	——	Exempt (reciprocity).	Maximum, 20 m.;
FLORIDA	Tax Collector of County.	Less than 10 h. p., $3; 11-20 h. p., $5; 20-40, $10. 41-50, h. p., $15; 51-60, $20; 61-70, $30; over 70, $50.	Annual	October 1st.	No examination.	Chauffeurs, $2.	——	——	Exempt, 15 days.	No general speed limits.
GEORGIA	Sec. of State, Atlanta.	$5.00.	Annual	March 1st.	None.	None	——	——	Exempt, 30 days.	
IDAHO	Sec. Highway Commission, Boise	20 h. p. or less, $15. 20-40, $20; 41-60, $25; over 60, $40	Annual	January 1st	No examination.	——	——	——	Exempt (reciprocity).	Prima facie evidence of excess; 20 m. per hour for ¼ mile.
ILLINOIS	Sec. of State, Springfield.	[illegible]	Annual	January 1st.	Owner's sworn application. Chauffeur's examination.	Chauffeurs only, $3 original; $2, renewal.	Annual.	Jan. 1st.	Exempt, 60 days.	Prima facie evidence of excess; cities, 10 m.; open country, 20 m.

*See page 557 relative to Ill. light law. In some of the states these laws may have been changed. See page 485 for requirement of light lens.

INDIANA	Sec. of State, Indianapolis.	Up to 25 h. p., $5; 25-40, $8; 40-50, $18; over 50, $30. Elec., $8; commercial, $5. Trade, $25; dup. plates, $1.	Annual	January 1st.	Examination, chauffeurs only.	$2.00	Annual.	Jan. 1st.	Exempt, 60 days.	Business portion, city or town, 10 m.; residence, 15 or 20 m.; open country, 25 m.
IOWA	Sec. of State, Des Moines.	20 h. p. or less, $8; over 20, 40 cents per h. p.; electric or steam, $15; trade, $15; each set of dup. tags, $1.	Annual	January 1st.	None.	——	——	——	Exempt (reciprocity).	Presumptive evidence of excess; over 25 m.
KANSAS	County Treasurer.	$5. Trade: register one car of each class.	Annual	July 1st.	No examination.	——	——	——	Exempt, 30 days.	Cities or towns, 12 m.; open country, 25 m.
KENTUCKY	Sec. of State, Frankfort.	Less than 25 h. p., $6; less than 50 h. p., $11; 50 h. p. and over, $20. Trade: one registration in each class.	Annual	January 1st.	No examination; no license.	——	——	——	Exempt (reciprocity).	Prima facie evidence of excess: cities, 10 and 15 m. for ¼ m.; open country, 20 m. for ¼ m.
MAINE	Sec. of State, Augusta.	20 h. p. and under, $5; 21-35 h. p., $10; over 35 h. p., $15. Trade: $25, registering all vehicles.	Annual	January 1st.	Examination optional with Sec. of State.	All operators, $2.	Annual.	Jan. 1st.	Exempt, 30 days.	Cities and towns, 10 m.; open country, 25 m.
MARYLAND	Com. of Motor Vehicles, Baltimore.	10 h. p., $3; 20 h. p., $10; 30 h. p., $15; 40 h. p., $20; over 40, $25. Trade: $6 per car or flat sum $100.	Annual	January 1st.	Examination optional with Commissioner.	Owners, $2 perpetual, chauffeurs, $5.	Annual.	Y. from date.	Exempt, 2 periods of 7 days reciprocity.	Prima facie evidence of excess; cities, 18 m.; open country, 25 m.
MASSACHUSETTS	State Highway Commission, Boston.	Under 20 h. p., $5; 20-29 h. p., $10; 30-39 h. p., $15; 40-50 h.p., $20; 50 h.p. up, $25. Trade: $3 car.	Annual	January 1st.	Examination for chauffeurs.	All operators: original, $2; renewal, 50c; exam., $2.	Annual.	On date of issue.	Exempt (reciprocity). (3).	Prima facie evidence excess: open country, 20 m. for ¼ m.; cities, towns, 15 m. for ¼ m. or more than 8 m. where view is obscured.
MICHIGAN	Sec. of State, Lansing.	$3. Manufacturers and dealers, $10; $2 duplicate sets of plates.	Annual	January 1st.	No examination.	Chauffeurs, $2.	Annual.	Jan. 1st.	Exempt (reciprocity).	Business portions, 10 m.; elsewhere, cities and towns, 15 m.; open country, 25 m.
MINNESOTA	Sec. of State, St. Paul.	$1.50. Trade: $10.00, with $1.00 for each set of duplicate tags.	Triennial.	January 1st.	Examination.	Chauffeurs, $3 first year; $2 annually thereafter.	——	Jan. 1st.	Exempt, 30 days.	Prima facie evidence of excess; cities, 15 m. for ¼ m.; open country, 25 m. for ¼ m.
MISSISSIPPI	State Auditor, Jackson.	$2 per vehicle perpetual and 36c. per h. p. annual.	Perpetual.	June 1st.	——	——	——	——	Exempt, 60 days.	——
MISSOURI	Sec. of State, Jefferson City.	Up to 12 h. p., $2; 12-23 h. p., $3; 24-35, $5; 36-47, $7; 48-50, $8; 60-71, $10; 72 h. p. up, $12. Trade: $10.	Annual	February 1st.	No examination.	Chauffeur's license only, $1.50.	Annual.	Feb. 1st.	Exempt, 20 days.	Over 25 m. for ¼ m. presumptive evidence of excess.
MONTANA	Secretary of State, Helena.	Trade, $10; for each type, $2.	Perpetual.	January 1st.	No examination.	Chauffeur's license, $2.	Perpetual.		Exempt.	Reasonable and propet.
NEBRASKA	Sec. of State, Lincoln	$2.00. Trade: register one vehicle of each class.	1 year from issue.	——	No license.	——	——	——	Exempt 30 days at a time.	Cities and towns, 12 m.; open country, 25 m.
NEVADA	Secretary of State, Carson City	12½ cents per h. p.; $2.50 minimum. Trade: registers one vehicle of each type, dup. plates, $1.	Annual	January 1st.	No examination.	No fees.			Exempt 30 days.	Reasonable and proper.
NEW HAMPSHIRE	Sec. of State, Concord.	Up to 15 h. p., $10; 16-30, $15; 31-40, $20; 41-50, $25; 51-60, $30; over 60, $40. Trade: $23.	Annual	January 1st.	Examination.	All operators; see (4) below.	Annual.	Jan. 1st.	Exempt ten days. (3).	Conclusive evidence excess: city or town, 15 m. for ¼ m.; open country, 25 m. for ¼ m.
NEW JERSEY	Com. of Motor Vehicles, Trenton, N. J.	10 h. p. or less, $4.50; 11-29 h. p., $7.50; 30 h. p. or more, $15. Trade: one number for 5 cars, $6 per car.	Annual	January 1st.	Examination. All new operators.	Less than 30 h. p., $2; 30 h. p. and over, $4.	Annual.	Jan. 1st.	Reciprocity, 15 days.	Cities, 12 m.; open country, 25 m.
NEW MEXICO	Sec. of State, Santa Fe	Less than 12 h. p., $2; 12-19, $4, 20-29, $6, 30-39, $8; 40-49, $10, 50 or more, $12. Dealers, $12.	Annual	January 1st.	None.	——	——	——	Exempt, 60 days.	No general speed limits.
NEW YORK	Sec. of State, Albany, New York & Buffalo	25 h. p. or less, $5; 25-34, $10; 35-49, $15; 50 h. p. up, $25. Trade: $15. $1 for each duplicate tag.	Annual	February 1st.	Examination. Chauffeurs only.	$2 for examination; $3 license fee; renewal, $2.	Annual.	Feb. 1st.	Exempt (reciprocity).	Presumptive evidence of excess; 30 m. for ¼ mile.
NORTH CAROLINA	Sec. of State, Raleigh.	Up to 25 h. p., $5; 25 to 40 h. p., $7.50; over 40 h. p. $10. Trade: $10; duplicate plates, $1.	Annual	July 1st.	None.	——	——	——	Exempt, 15 days.	Business portion, city or town, 10 m.; residence, 15 m.; open country, 25 m.
NORTH DAKOTA	Sec. of State, Bismarck.	$3.00.	Annual	January 1st.	None.	——	——	——	Exempt.	Cities and towns, 10 m.; open highway, 30 m.
OHIO	Sec. of State, Columbus.	Gasoline and steam vehicles, $5; electric, $3. Trade: $20 for each make (motive power) of machine.	Annual	January 1st.	Chauffeur's examination only.	Chauffeur's license only, $3.	Annual.	Jan. 1st.	Exempt.	Closely built up, 8 m.; cities, 15 m.; open country, 20 m.
OKLAHOMA	Highway Commissioner, Oklahoma City.	$1.00	Annual	January 1st.	No examination.	No fees.	——	——	Not exempt.	No speed limits.
OREGON	Sec. of State, Salem.	Electric vehicle, $3 and $5; others: 26 h. p., $3; 27-36, $5; 37-40, $7.50, above 40 h. p., $10. Dealers, $10.	Annual	January 1st.	No examination.	Chauffeur's license only, $2 (5).	Annual.	Jan. 1st.	Exempt, 30 days.	25 m.
PENNSYLVANIA	State Highway Dept., Harrisburg	Up to 20 h. p., $5; 20-35 h. p., $10; 35-50 h. p., $15; 50 h. p. up, $20. Trade: $10 per car, 10 cars per application, half fees after July 1. Solid tires by weight.	Annual	January 1st.	No examination; see (6) below.	Chauffeur's license only, $2.	Annual.	Jan. 1st.	Exempt (reciprocity).	24 m.
RHODE ISLAND	State B'd Pub. Rds., Providence.	20 h. p. or less, $5; over 20 h. p., $10; over 30 h. p., $15; over 40 h. p., $25; trucks, $7. Trade: $50.	Annual, from date of issue.	——	Must show knowledge.	All operators, $2.	Annual from date of issue.	——	Exempt, 10 days.	Cities and towns, 15 m.; open country, 25 m.
SOUTH CAROLINA	Clerk County Court.	$1.00.	——	——	None.	——	——	——	Not exempt.	15 m.
SOUTH DAKOTA	County Treasurer.	$6.00. Trade: $10; $2 per set dup. plates.	Annual	January 1st.	None.	——	——	——	Exempt (reciprocity).	25 m. presumptive excess.
TENNESSEE	Sec. of State, Nashville.	Secretary of State, $2; County Clerk, $1.	Perpetual.	——	None.	——	——	——	Not exempt.	20 m.
TEXAS	County Clerk.	0.50.	——	——	None.	——	——	——	Not exempt.	City or town, 6 m.; open country, 18 m.
UTAH	Sec. of State, Salt Lake City.	$2. Manufacturers and dealers, $2 for each style of machine.	Perpetual.	——	No examination.	Chauffeur's license only, $2.	Perpetual.	——	Exempt.	Closely built up, 10 m.; elsewhere, city or town, 15 m.; open country, 20 m.
VERMONT	Sec. of State, Montpelier.	First year, $1 per h. p.; second year, 75% of first; third year on, 50% of first registration. Trade: $25.	Annual	January 1st.	Examination discretionary with Sec.	All operators, $2.	Annual from date of issue.	——	Exempt (reciprocity). see (7) below.	Prima facie evidence of excess; city or town, over 10 m.; open country over 25 m.
VIRGINIA	Sec. of Commonwealth, Richmond.	20 h. p. or less, $5; over 20 h. p. and under 45 h. p., $10; 45 h. p. and over, $20. Trade: $50.	Annual	January 1st.	No examination.	Chauffeur's only, $2.50.	Annual.	Jan. 1st.	Exempt 2 periods of 7 consecutive days.	Cities, 8 m.; open country, 20 m.
WASHINGTON	Sec. of State, Olympia.	$2.00.	Annual	June 1st.	None.	——	——	——	Exempt.	Business portion of city or town, 12 m.; open country, 24 m.
WEST VIRGINIA	State Aud., Charleston.	$10.00	Annual	July 1st.	No examination.	Chauffeur's license only, $2.	Perpetual.	——	Exempt (reciprocity).	Cities, 15 m.; open country, 20 m.
WISCONSIN	Sec. of State, Madison.	$5. Trade: $10 for each garage with 6 number tags; additional tags, 50 cents each.	Annual	January 1st.	None.	——	——	——	Exempt.	Cities and towns, 15 m.; open country, 25 m.

ADMISSION OF CARS INTO CANADA.

The customs regulations governing the temporary admission of motor cars into Canada, as contained in memorandum No. 1571B, in force April 1, 1910, and reprinted below, require generally a bond for double the estimated duties and a deposit of $25. For motor cars remaining in Canada not more than three days, a permit is issued, apparently without deposit or bond.

1. Motor cars manufactured abroad and not duty paid, when imported into Canada by the owners personally who are non-residents of Canada or temporary visitors therein, may be admitted under bond or upon cash deposit, for owners for touring purposes only, provided the owner is in nowise connected with any motor car business and that the machine is not to be used for any commercial or business pursuits whatever while in Canada, and subject to the following regulations and conditions:

(a) The motor car shall be reported on form approved (E29½) in duplicate, at the customhouse at the port of importation, where a careful examination and appraisement shall be made.

(b) As invoice showing the selling price of the motor car shall be produced when practicable, as an aid to the collector in determining the value.

(c) Upon receiving a deposit of $25 and a bond executed in Canada in approved form for double the estimated duties, conditional for the due exporation of the motor car covered thereby within three months from date of bond, the collector may grant a permit accordingly, to be indorsed on the duplicate report, for the use of the motor car in Canada for touring purposes.

(d) The bond shall be signed by the importer and by two residents; or by the importer and by a resident of Canada who has deposited with the collector of the port of entry, the general guaranty of an incorporated guaranty company, authorized to do business in Canada, and which guaranty is then available as a security in the case; provided, that the special bond of an incorporated guaranty company authorized to do business in Canada, may also be accepted, in approved form, instead of the bond first herein mentioned, and that the cash deposit of $25 may be dispensed with in any case covered by a special or general guaranty bond.

(e) The bond shall be filed by the collector with the tourist's report attached, and the duplicate report shall be handed to the tourist with permit and receipt for deposit indorsed thereon.

(f) The deposit shall be subject to refund by the collector upon return of permit, with proof of the exportation of the motor car within three months from date of bond. In default of the exportation of the motor car with proof of such exportation, to the satisfaction of the collector within three months from the date of importation, the deposit is to be entered as customs duty, and the provisions of the bond enforced.

(g) The term "motor car" herein is to be held as including the outfit accompanying the motor car.

2. Motor cars manufactured abroad and not duty paid, may not be reimported for touring purposes within six months from the time of their exportation after previous entry in bond for touring purposes. This limitation, however shall not apply to motor cars provided for in the section next following:

4. The regulations in memorandum 940B, of July 31, 1897, concerning teams and carriages crossing the frontier, provide that where the persons in charge of such teams and carriages are well known to the customs officer, he may allow the outfit to cross the frontier and return within one week, subject only to the usual report, search and examination. This provision may be extended to tourists' motor cars when the customs officer is satisfied that the motor cars will be used only within the limits of the port of importation, and vicinity in conformity with customs, laws and regulations.

British Columbia.

Write The Western Canadian Motorist, Fourth Floor, World Bldg., Vancouver B. C. for copy of the laws. The registrations are made with the superintendent of Provincial Police.

Vancouver, B. C. have a street traffic by-laws issued by the city of Vancouver.

Quebec.

Quebec Moto-Vehicle Laws can be obtained from The Provincial Treasurer, or Mr. C. F. Dawson, Collector of Inland Revenue; City Hall Montreal, Quebec.

Canal Zone.

Write to Colonel Chester Hardy, Governor—for information.

CHAUFFEURS' EXAMINATION QUESTIONS.

The questions below are not a standard set but merely gives an idea as to the questions sometimes asked the applicant for chauffeur's license, in those states requiring examination. In some states the applicant must also show his ability to drive a car.

Q. 1.—What vehicles usually have the right of way in large cities?

A.—Fire department, ambulance, mail wagons and heavily loaded trucks, police and emergency wagons.

Q. 2.—What do you do when running parallel to a street car and the latter stops to allow passengers to alight?

A.—Slow up, stop, or pass 8 feet away.

Q. 3.—What would you do if your car caught fire?

A.—Turn off gas at supply pipe, smother flames with coat, blanket or sand (do not use water) and get a fire extinguisher into action as quickly as possible.

Q. 4.—Of what use is the carburetor to a gasoline engine?

A.—It mixes air with the gasoline in proper proportion.

Q. 5.—How can you detect when your engine is losing compression?

A.—By loss of power when running, or by cranking slowly to test each cylinder, or by a hissing noise on compression stroke.

Q. 6.—What would you do when climbing a hill and your brakes refused to hold and your gear refused to mesh?

A.—Back car crossway of road.

Q. 7—What would you do if ascending a hill at a high rate of speed and a car crossed your path from a crossroad?

A.—Blow horn and slow up, or stop or turn car in same direction as other car is running.

Q. 8.—How would you ascertain the amount of gasoline in your tank at night?

A.—Measure it with a stick or rule, being careful to keep any flame away from opening of tank.

Q. 9.—What offense would justify a magistrate to revoke your license?

A.—Driving while intoxicated or trying to escape after an accident on the highway.

Q. 10.—How can you tell when your differential is out of order?

A.—By unusual noises or if both rear wheels do not run evenly after ascertaining that the brakes do not need adjusting.

Q. 11.—What precautions do you take in driving on a dark or rainy day?

A.—Put on skid chains drive slowly and carefully.

Q. 12.—What action would you take if you injured any person on a highway?

A.—Stop and render any assistance possible, notify an officer.

Q. 13.—What are several causes of your engine overheating?

A.—Lack of water, no oil, running on too rich a mixture or too far retarded spark, loose or broken fan belt.

Q. 14.—What are the road and street speed laws of most cities?
A.—Not allowing to run over 30 miles an hour, and 4, 6 or 8 in the city; use judgment.

Q. 15.—What are the causes of the rear tires wearing unevenly?
A.—Wheels out of alignment, brakes out of adjustment.

Q. 16.—How would you start the car if unable to turn the crank?
A.—Jack up the rear wheel, putting speed lever into high gear. After starting the engine, put the lever in neutral.

Q. 17.—What would you do if your engine stalled in the middle of a R. R. track?
A.—Flag a train that may be approaching or push car off track, put speed lever in neutral and start engine as quickly as possible.

Q. 18.—What is the cause of light smoke issuing from the exhaust pipe?
A.—Too much oil in crank case or lubricator improperly adjusted.

Q. 19.—In what position would you leave your car at the curb?
A.—As near the curb as possible, right side on.

Q. 20.—What precaution would you observe in driving near a fire hydrant and discharging passengers from your car?
A.—Stop at least ten feet from the hydrant. (varies from 6 to 20 feet.)

Q. 21.—What is your spark lever for?
A.—For controlling the timer or breaker on the magneto.

Q. 22.—What is your gas lever for?
A.—For controlling the amount of fuel for the engine.

Q. 23.—What is your accelerator for?
A.—A foot control for the throttle.

Q. 24.—What is the clutch on your car for?
A.—For engaging or disengaging the engine from the driving wheels.

Q. 25.—What is the difference between a contracting and an expanding band brake?
A.—An expanding brake expands on the inside of the brake drum, while a contracting brake tightens around the outside of the drum.

Q. 26.—What equipments are required by law on motor vehicles?
A.—License number plates on front and rear of machine, 2 side lamps, 1 tail lamp and horn or other signaling device.

Q. 27.—What should be the position of the speed lever in starting an engine?
A.—In the neutral position.

Q.28.—How many kinds of brakes are there on automobiles?
A.—Two; running or foot brake and emergency or hand brake.

Q. 29.—What is the difference between the jump spark and the make and break system of ignition?
A.—In the jump spark, a coil or transformer is used, causing a high tension current; in the make and break, the spark is caused by making and breaking the primary current.

Q. 30.—What is the purpose of check valves?
A.—Check valves are used to prevent the return of a liquid, gas or air after having passed it.

Q. 31.—What is an inlet chamber?
A.—A part of the cylinder which encloses the inlet valve.

Q. 32.—What is an inlet valve?
A.—The valve which opens during the suction stroke of the piston, allowing the mixture or gas to enter the cylinder.

Q. 33.—If when traveling on the public highway you discovered some fault with your steering device. what would you do?
A.—Stop at once and fix it.

Q. 34.—How can you tell the difference between a high and a low tension magneto?
A.—By looking at it. A high tension magneto is used in the jump spark system without the use of a separate coil or transformer, if there was a separate coil I would know it was a low tension magneto.

Q. 35.—What system of ignition has a low tension magneto.
A.—Make and break or magnetic plugs or with a separate high tension coil.

Q. 36.—What system of ignition has a high tension magneto?
A.—Jump spark system.

Q. 37.—If engine could not pull the car up a hill on high speed, what would you do?
A.—Change into next lower gear.

Q. 38.—If engine was not powerful enough to pull the car up a hill on first or low speed. what speed would you use?
A.—Turn the car around and go up on reverse.

Q. 39.—How would you separate water, gasoline and other foreign substances?
A.—Strain through chamois or fine wire gauze.

Q. 40.—Name several conditions which will cause an engine to knock or pound?
A.—Loose bearings, feeding too much gas, or running on too far advanced spark, and preignition from carbonised cylinders.

Q. 41.—Name all parts of an automobile that should be lubricated and state whether oil or grease should be used?
A.—Oil in lubricator for main bearings, connecting rods and piston; heavy oil or grease in transmission, differential, steering gear, universal joints and hub caps.

Q. 42.—If driving on a road and you should wish to pass a vehicle moving in the same direction. directly in front of you, which side of the vehicle would you pass, right or left?
A.—Left side.

Q. 43.—What will cause a back fire in the carburetor?
A.—Broken, sticking or leaky inlet valve.

Q. 44.—What is meant by one blast of a traffic police whistle at a street crossing?
A.—Proceed east and west traffic.

Q. 45.—What will cause a back fire in the muffler?
A.—Engine missing fire or too rich a mixture.

Q. 46.—John Smith, a duly licensed chauffeur. operates a motor vehicle under the new law, and accompanied by a friend. May the friend drive the car?
A.—No, not unless John Smith retains complete control of the car.

Q. 47.—What are you required to do when a horse or other animal on the highway appears frightened?
A.—Slow up or stop, if necessary. On a narrow country road it may be necessary to stop the engine.

Q. 48.—If you wish to stop your car and your foot brake does not hold, what would you do?
A.—Use the emergency or hand brake.

Q. 49.—How often is it necessary to examine your brakes?
A.—Every day you get out.

Q. 50.—In the event of a vehicle coming towards you on the highway, what precautions would you take?
A.—Keep to the right; blow horn, if necessary.

Q. 51.—What are the controlling parts of an engine?
A.—Spark and gas levers, clutch, brake, speed-lever and the steering wheel.

Q. 52.—How would you control your car going down a steep incline?
A.—Retard spark and gas, put machine in low gear, switch off ignition, and, if necessary, also use hand brake.

Q. 53.—What would you do if a car while proceeding in front of you suddenly swung around in your course?
A.—Slow up or stop, blow horn, hold out hand or operate signal light as warning to anyone in rear.

Q. 54.—What is the speed limit in crowded city streets?
A.—Four to six miles per hour.

Q. 55.—What penalty is there, according to law, for any person driving a car while in an intoxicated condition?
A.—Felony; revoke license perhaps.

Q. 56.—What position should the controlling parts of engine be in starting?
A.—Speed lever in neutral, emergency brake on, spark retarded and gas lever slightly advanced.

Q. 57.—Why is the spark lever advanced after starting the engine?
A.—To make the spark take place sooner in relation to the position of the piston in the cylinder; that is instead of the spark taking place just over high center, it will then occur on the high center, or just before when running fast.

Q. 58.—What effect will too far advanced spark have on the engine?
A.—It will cause a metallic knock in the cylinder and might break a connecting rod or cause engine to overheat.

Q. 59.—What is the timer or commutator for?
A.—For timing the spark.

Q. 60.—Should you be going south on a busy street and you wished to turn west, how would you turn.
A.—Slow down to four miles an hour, hold out hand as signal for vehicles in rear and turn west, keeping northwest of center crossing.

Q. 61.—Should you be going north and you wished to turn west, how would you turn?
A.—Slow down to four miles per hour, hold out hand as signal for vehicles in rear, and turn west, keeping northeast of center of crossing.

Q. 62.—What would be the penalty in taking a car without permission of the owner or authorized agent of same?
A.—Felony; revoke license, perhaps.

Q. 63—What signal would the driver of a horse vehicle give you should he want you to stop?
A.—Hold up his hand or whip or perhaps shout.

Q. 64.—What precautions would you take before crossing a railroad track?
A.—Watch for an approaching train; drive carefully.

Q. 65.—What part of a carburetor is the mixing chamber and what is it for?
A.—That part directly over nozzle of jet usually placed in the center, and is used for mixing the gas and air.

Q. 66.—How would you time a car with magneto ignition and how would you time it with battery ignition?
A.—With battery ignition the spark occurs about 1/16 of an inch over high center of compression; with magneto the spark is set to occur on high center.

Q. 67.—What is the float in the float chamber for?
A.—To regulate the level of the gasoline.

Q. 68.—Draw a diagram of the manner in which you would make a turn in a busy street intersection.
A.—.......... ....

Q. 69.—Where is the differential on a shaft driven car, and where is it on a double chain driven car?
A.—In shaft driven cars on the rear construction, in double chain driven cars, on the jack shaft.

Q. 70.—What would you do if you saw an automobile or any other vehicle trying to escape from justice after injuring a person on the public highway?
A.—Take his number and render any assistance I could to apprehend the offender.

Q. 71.—What is the penalty for a person trying to escape after such an accident; what is the nature of the crime he is committing?
A.—Felony; his license could be revoked.

Q. 72.—What is gasoline used for?
A.—It is used for fuel.

Q. 73.—What signal would you give cars behind you, if going to make a turn? if stopping?
A.—Hold your hand out to the side of car or flash signal light.

Q. 74.—What will cause the cylinders to carbonize?
A.—Too rich a mixture or too much oil being used in lubrication.

Q. 75.—What is meant by three blasts of a police whistle?
A.—An alarm signal; all vehicles pull as close to the curb as quick as possible and stop.

Q. 76.—What would you do should you be going along a country road at the rate of 35 miles per hour and a car should cross your path suddenly?
A.—The law is 30 miles per hour, and you should not be driving 35. Blow horn and stop or turn in same direction other car is going.

Q. 77.—What precautions should be taken before taking out a car?
A.—See that there is water in the radiator, gasoline in the tank, oil in the lubricating system, tires properly inflated, lamps (2 side and 1 tail) filled, battery charged horn, and license plates in place.

Q. 78.—Can the ordinary car run without a differential?
A.—No, not around corners without injury or wear to tires.

Q. 79.—How early and how late would you light your lamps?
A.—Light them one-half hour after sunset and put them out one-half hour before sunrise, or be governed by weather conditions.

Q. 80.—How many kinds of transmissions are there in general use today?
A.—Three; sliding gear, planetary, and friction disk.

Q. 81.—What is meant by timing your engine?
A.—Setting the valves so that the inlet opens and the exhaust closes, according to marks on fly wheel, and setting clearance of valves.

Q. 82.—I was running along on a smooth level road and my car was going O. K. when I came to a slight grade, my car suddenly slackened and did not seem to respond to the accelerator. Investigation proved that it was not carburetor trouble. What was it?
A.—The connection between the magneto and my spark lever had become disconnected.

Q. 83.—My engine was running on magneto; on throwing off the switch the engine continued to run; the switch was found O. K. What was the trouble?
A.—Magneto ground wire was broken and the break was hidden by the insulation.

Q. 84.—If while running close behind another car, the said car should turn suddenly, what would you do?
A.—Swing with the other car, or in the same direction.

Q. 85.—Your car running slowly on high gear, and you started to cross a car track and failed to notice a fast approaching car before it was close upon you; you accelerated with the result that your engine stalled and your car was wrecked. What would have been the better thing to do?
A.—Shifted to next lower gear before accelerating, then engine would not have stalled and tracks most likely would have been cleared.

POINTERS ON SELECTING A CAR.

What is the car required for? This is one of the first questions to be asked. For pleasure purpose only a standard type of body may be chosen, but for business uses the selection is more restricted, should any particular requirements in the matter of accommodation have to be met. Road conditions of the country it is intended to be used in, is a great consideration. Confined to any particular districts, a car with a given gear and engine power could be advantageously adopted which would not give perhaps universal satisfaction. Thus in a flat district, a low powered car will do efficiently and infinitely more economically what in a hilly country would necessitate perhaps twice the power to do the work at all. Most cars will "climb any hill," for instance—yes, but some of them only at a very slow pace, which becomes too tedious in a really hilly country.

Constant attention necessary. Whether you intend to keep a mechanician to look after your car, or whether you intend to look after it yourself, is another point to consider. There is a limit to the size of a car which the owner can, (if it is in pretty constant use), attend to in all respects personally with success, unless he be a man of great leisure, and moreover, keen enough to put up with much of the drudgery involved. To obtain best results in running and the greatest economy in upkeep, it is useless to attempt to conceal the fact that constant attention must be paid to a car when it is at home, and where the average man can easily find time to do ample justice to a moderate-sized car, a large car might be too much for him in the amount of attention required.

What type of body. This is not much a matter of choice nowadays, as the cars are built in large quantities and to standard type, but it is possible to select a body suitable for the purpose you intend to use a car mostly. Putting aside for the moment the case of those who, from consideration of price alone, would confine themselves to a car of power and size suited for a two seated body only, it is best to have a four-seater if only a small one. A very sensible roadster called a "clover-leaf" type of roadster, seating two in front and two in the rear is now very popular. Though the back seats may be used only once in a while, they are nevertheless too often wanted if not there, and the advantages of being able to give friends a lift and of having plenty of room for luggage and parcels are well worth the slight difference in extra cost.

Should some form of optionally covered car be desired, then the "one man" type of top is the simplest and most serviceable form of removable cover, and in combination with a glass front or wind shield and suitable side curtains, will transform an open car in a very few minutes into a tolerably weather-proof vehicle. The coupe and cabriolet (page 16) car is very popular for all year 'round use; in the summer the top of coupe keeps the sun off, and, as the windows and front can be raised, the car is really cooler than an open car. In the winter this coupe, coupelet or sedan is very comfortable. A closed car of this type also tends to keep the dust and dirt out, (if the back is closed), and is becoming more popular, as the motorist is now looking for comfort more than speed.

The sedan enclosed car is used principally where the owner drives his own car and desires something enclosed and wishes to carry more than three. The limousine is an enclosed type of car employing a chauffeur.

When once the prospective customer has made up his mind to become an actual buyer, he should fix a price limit. With many people this fixes itself; that is to say, their means enable them to decide in a very short time how far they can go. In any event, to arrive at a maximum figure is the first step toward that process of mental "weeding out" which has to be gone through when so many, and so great a variety of values are offered. Cars can be obtained at prices from $390 upward, and in all calculations a sum not less than, say $50 to $100 for a small car, and so on in proportion to size will probably have to be laid out, in addition to the purchase price, in acquiring those accessories, spare tires and tubes, which are necessary, and all of which are not always "thrown in" with the car. A good runabout, seating two, can be had for $390 to $750, and as much as $6,000 may be spent on a high grade six, eight or twelve cylinder car.

The most luxurious and smooth running gasoline cars have, as a special refinement, six, eight and twelve cylindered engines, which are wonderfully silent and elastic, and enable the change speed gear to be almost dispensed with; but the cost of cars of this type renders such cars expensive, although I note that a very good car of six cylinder type can be had for $1,350.

Sometimes we are asked the question, "**which is the best car to buy,**" I will tell you how I would settle the choice, if I were unable to decide otherwise. Go to a used car concern and ascertain which car brings the best price or what make of cars sell more readily than others. This may help to answer the question.

Cost of running—or up-keep: Here lies the crux of the whole matter. Closely allied with the important question of original outlay is that of running cost, which must be taken into consideration to a certain extent, when buying. The size of the bill for up-keep bears, of course, a direct proportion to the mileage done. As regards fuel consumption, the item will not be found a large one in any car up to, say, 25 horse-power, unless there is some radical defect in the system or temporary want of adjustment. In large and heavy cars the gasoline bill quickly mounts up.

The largest item in the cost of running is always that for tires, and this charge becomes heavier as the speed increases, and is, of course, again directly proportionate to the mileage run. It is not possible to give any general figures which would be of any use, but the statement may be made that no man, who can afford according to his means, a car up to say, 25 horse-power, is likely to be frightened at cost of upkeep unless he is very careless in his choice of a car, and, moreover, very unfortunate subsequently in the handling of it.

Tires: The main feature to insist on about a car is the pneumatic tires. Insist on their being ample size and weight to support the car at high speeds. Small, light tires spell constant punctures and troubles, not to mention short life. There is little to choose between the several makes of good tires available, and the manufacturers' lists give the maximum weight per wheel, which the various strengths and types are intended to carry, it being a good rule to keep well within the limits.

The disadvantage of fitting lighter tires to the front than to the rear wheels is that the convenience and benefit of interchangeability is lost Some form of non-skid tire should be used for the rear, this extra rubber costs but a very little additional amount, and the extra wear from the extra amount of rubber, to say nothing of the non-skid qualities, is worth the difference. In fact they are economical to use on all four wheels.

Solid tires are out of the question for vehicles traveling over eighteen miles per hour; we often see them on electric vehicles, and the owner feels quite contended that he is saving money by putting the solid tires in place of the expensive pneumatic tires, but it will only be a short time before the vibration will jolt and jar the paste from the cells of the batteries, and new batteries are more expensive than pneumatic tires. The quick detachable demountable rim, and pneumatic tire is the most desirable of the lot; the tire is the same construction as usual (clincher), but the difference is in the rim. With the quick detachable rim, it simplifies the changing of a tire, but when you carry a quick detachable tire on a rim, which can be replaced on your wheel instead of the other rim, and with the tire already inflated, imagine the saving of time and labor.

The ignition system: There are three popular methods for obtaining the electric spark, namely, by high-tension magneto machine, together with coil and battery, the latter being used to start the engine, and after started, the magneto supplies the current for ignition; this system is called "dual" system. Another system is a low-tension magneto, supplying current to a high-tension coil, thence to the spark plug. This system is also called a "dual" system when used in connection with a battery to start the engine on. The third system is the battery, coil and timer system as the Atwater-Kent, Connecticut or Delco. This system, with the automatic advance used in connection with the generator and storage battery is the popular systems in general use. (See pages 255 and 254.)

*Judging a Second-Hand Car.

For the past several years over sixty per cent of the automobiles manufactured in the U. S. have been bought by people buying their first car. It is becoming a more complex matter nowadays to purchase a motor car that will give satisfaction in every possible way.

The prospective owner looks over a number of cars and when he is through he is more confused than ever. He finally buys a machine and, as the saying goes, if he has luck he has bought a satisfactory car. But the chances are that his first purchase is most unsatisfactory, in fact a lemon and he has been squeezed for a round sum.

Usually after his first or second bitter and expensive experience he uses more caution and foresight and then he has learned to buy a good car. But it was costly, and at times humiliating, he could have made a wise selection the first time.

Many things are to be considered in buying a car today. There are a great many different cars on the market and in a large number you are not getting your money's worth. It behooves a careful buyer to weigh the merits and demerits of each car with prudence, to the end that the car he buys gives him comfort and satisfaction in every practicable way.

He should know about the factory behind the car he intends to buy. He should look over the record of previous cars put out by the same concern, and ascertain the reliability of the company and the service it gives (in regards to repair parts) the owner, after he has bought the car.

He should know, without a doubt, the material used in the important parts of the car and which kind is best. In the past some cars have had cardboard or pressed paper bodies. Others have used a cheap iron or malleable iron castings instead of more expensive steel drop forgings and they have bent or broken at a critical time endangering the lives of the occupants of the car. The design of some cars may not be as pleasing as some others, but if the material is there, the car will surely stand up and give satisfaction.

The following pointers on selecting a second hand car will give the prospective purchaser an outline to follow:

Ascertain the age, make and type. Are the makers still in business, with a view of being able to get spare parts. Get exact dimensions of the cylinders and approximate number of revolutions and apply the formula given under "Horse power" page 542 and obtain an idea of what the power really should be.

Do not get any ugly or antiquated looking car—you may want to sell it again. Inspect its general condition.

Inspect the transmission, and condition of its gear wheels, this will give an index as to how much wear it has had.

If chain-driven the wear can be judged by the condition of the chain. Jack up back axle and revolve the wheels and see if the differential works smoothly and if it runs true—same with steering wheels, also the steering gear; considerable back lash is a bad sign.

Examine tires, see make, then inquire of tire makers and see if the particular size can be obtained and is not obsolete.

Test engine for good compression. Run engine and see if it will slow down and run very slowly. Inspect the radiator system and see that it is not patched up, or otherwise in a shaky condition. The water ought not to steam, but will naturally get warm. Examine the ignition and wiring system; study up on the ignition subject and see if it is up to date and will not likely give trouble.

For a final test, run the car with a full load of passengers—make a 25-mile run with at least one good steep hill, 1 to 8 per cent grade. A car which will not go up such a hill is of little practical use. Note if engine pounds when making the run and after the run note if bearings are hot and if water is steaming.

Do not judge a car by its outside appearance—paint is ordinarily cheap, but when it is used to cover a worn out auto, it is dear at any price.

†Selecting a Commercial Car.

There is a distinction between a truck and a delivery wagon, see instruction. Some of the important points to be decided are:

What type of car for your particular needs—gas or electric?

What horsepower?

How many pounds capacity shall it have?

Should several cars be used or one big one?

Shall it be equipped with penumatic or solid tires?

Can an inexperienced man be given charge of the running and repair work?

Is there any special equipment necessary for greater efficiency?

Should the car always be loaded to capacity?

Today there are motor trucks and delivery wagons of every conceivable size and design, therefore, it is the problem of the possible purchaser to choose carefully the kind of a car best fitted to serve their purpose with the greatest efficiency.

It is a very common sight to see a heavy type of delivery wagon make a trip of several blocks and sometimes miles to deliver one or two small packages or baskets of groceries when one of the smaller types of commercial cars could have done it just as well, and with greater efficiency, reducing materially the overhead cost. On the other hand, we have often seen a light delivery or a very heavy type of truck making a trip with an overload. This is just as impractical as an underload, for it will ruin the expensive motor equipment, making the car depreciation very considerable.

A very good rule to stick to closely is to have the car filled nearly to capacity on every trip that is made. A motor truck or delivery wagon should not be chosen having in mind a maximum or minimum load, but an average load. To get the greatest efficiency out of a commercial vehicle keep it loaded and moving the largest possible number of hours during the working day.

If electricity is produced in your own plant at a very low cost, and it is possible to secure a man who understands and can care for storage batteries, then it may pay to investigate the electric vehicle.

*Second hand car values is a problem. A popular Motor Trade Magazine publishes weekly the sales of second hand cars made in different large cities. The price they sell for, condition and year model, etc. is given. This is very handy information for the dealer.

†See Instruction 48 for "Commercial Cars."

INSTRUCTION No. 39.

THE AUTOMOBILE SALESMAN: Pointers Suggestions and Advice. Advantages and Disadvantages of Mechanical Features of Different Parts of a Car. Addresses of Auto Manufacturers.

Suggestions.

To become a successful auto salesman one must necessarily know the principle and construction of all parts of a car, not merely the car you propose to sell, but other makes of cars as well.

In our instructions we have endeavored to teach you the principle and construction of the various parts of all cars; for instance, we illustrated and described the different types of drives usually employed; the different types of clutches, ignition systems, carburetors, etc. The engine was thoroughly explained. You learned that all engines work on the same principle but the construction may vary, in that the valves may be on the side or overhead, but the principle is just the same; also the same with the ignition and other subjects.

Therefore, taking it for granted that the reader has thoroughly mastered the different principles involved, he must now figure out why one system is better for a certain purpose than another. He must also familiarize himself with all makes of cars in order that he will know just why different manufacturers are using one system and others another. For us to point out such a comparison would require an extra book—therefore, we will suggest to those who have fully made up their mind to become auto salesmen, to obtain the catalogues of the various leading automobile manufacturers. These catalogues are easily obtainable by writing a postal card for them.

***Obtain the address of the various manufacturers.** I would suggest that the student write one of the following publications for a copy of their paper and the ads of the leading manufacturers will appear therein:

Automobile Dealer and Repairman, 76 Murray St., New York; Automobile, 239 W. 39th Street, New York; Motor Age, 1200 Michigan Ave., Chicago, Ill.; Motor, 381 4th Ave., New York; Horseless Age, New York, Motor World, New York.

After obtaining the catalogues of the various manufacturers, the next step will be to take one at a time and study the specifications of each car. This will give you the principle of construction of that make of car. If, in reading the specifications, you do not understand the meaning, then turn to the "index" in this book and find the explanation. For instance, suppose one manufacturer says the cylinders of his engine are cast "en-bloc," turn to index and find "en-bloc" and then read what "en-bloc" means. Each manufacturer will explain why his system is the best; for instance, one manufacturer may claim his three point suspension best; if you do not know what this means, then look it up in the "index." In this manner the salesman student will acquire a considerable knowledge of the various automobiles, and also from reading the claims of each manufacturer he will be able to discuss the relative values of these claims.

While all this may appear simple and an easy way to acquire the information, it possibly was not thought of by you, and if you will take the time and pains to do as directed it will no doubt be of great value to you.

Auto salesmen are usually employed on a commission. The commission is usually 5 per cent. Auto dealers who are agents for automobiles are always on the look-out for good salesmen, and to be a good salesman you must study the points of the car and be able to explain to a customer "why" your particular car is the best. He must also be able to close a deal; that is, after convincing the prospective customer that the car is the best, he must clinch the sale as quickly as possible.

A salesman who thoroughly understands his car and also understands the construction of other cars and can explain "why" his system is superior, is the valuable salesman. He must get his prospects the best way he can. Quite often a prospective customer will call at the garage and inquire about a car—it is then that the wide-awake salesman is there, ready with his courteous and agreeable manner and willingness to explain.

Salesmanship Pointers.

A man who intends to buy a car feels as though he is making an investment and he will, no doubt, investigate the merits of all cars. It is then reasonable to suppose that the salesman who most thoroughly impresses this prospect that he knows the construction of his car and can explain its good points, will make a greater impression on him. If the salesman is fortunate enough to be able to cultivate a pleasing personality then he will be all the more likely to make a valuable man.

Remember, the average man is generally governed by the wishes of his family—he may select a car himself but on having the women folks pass on the purchase nine times out of ten, they will go entirely for "looks;" therefore, it is essential that a salesman not only be neat and tidy himself, but he must keep the car he used for demonstrating perfectly clean and well polished, and above all, in perfect working order. Many a sale has been lost by nothing more than some trivial trouble as running out of gasoline or engine heating from lack of water. While these troubles would be insignificant with an experienced person, they would handicap a sale because the prospect would not know, but would think it a defect in the car.

Don't attempt to make your sale on the weakness of the other fellow's proposition but on the strength of your own. Understand, and admit to your prospect that all methods of construction have some advantages for certain purposes, else they would never have been manufactured. Be prepared to intelligently discuss the different features of the leading cars and to explain why the features of your car are—not the "best in the world"—but the best for that particular man's need. Once you make him feel that the car has special advantages for him personally, the sale is made.

Does your Customer Buy—or Do You Sell him?

Don't take it for granted when a man walks into your salesroom, or consents to a demonstration, that the car is half sold. This is merely an introduction and it is still up to you to make the sale. And you can't tell from the cut of a man's coat how much money he has in the bank.

Selling automobiles is a merchandising proposition pure and simple, and it is your duty to give the customer the same amount of courtesy and attention that he receives in any high-class store. Buyers appreciate courtesy.

As John Lee Mahin once said: "The buying unit is the family," and you should as soon as possible ascertain the purpose to which the buyer wishes to put the car—who else is to be considered besides the prospect—and then shape your arguments accordingly.

**See page 533 for addresses of manufacturers, and charts 229 to 234 for "Specifications of Leading Cars."

Here is an actual instance: A man walked into the salesroom of a certain dealer. He was just an ordinary looking human being, possibly not quite up to the average in appearance. He did not walk right up to the proprietor, but wandered around among the cars on the floor. The dealer happened to be talking to a friend and was in the middle of a detailed description of a show he had seen the night before—so he allowed the unimportant looking stranger to remain unnoticed.

The cars could not talk—they can't sell themselves unaided, so the man finally walked out.

Just across the street there was a salesroom with newly painted front. A car was displayed attractively in the show window and the atmosphere of the whole establishment was up-to-date business methods. The window was clean and the interior presented an attractive, enterprising, inviting appearance. When the stranger stopped in front of the window a salesman immediately opened the door and invited him to step inside, where he could get a much better view of the car.

Once inside, the salesman asked: "Have you ever had any experience in operating a car?" This was a safe question and it opened the door at once for a friendly discussion. Every man is eager to tell about his own motor experiences, even if he has at one time owned even an antiquated one cylinder model. As the prospect told his experiences the salesman, without antagonizing him, was able to draw comparisons between the car the prospect once owned and the new car on display. No matter what manner of car a prospect has driven, he does not want his judgment questioned.

Often a man is just as sensitive to criticism about his car, as he would be about his personal appearance.

During the discussion the prospective customer mentioned the fact that his old car was not adapted for use by his wife and daughter. On the strength of this bit of information the dealer then called the prospect's attention to the fact that the car on display permitted access to both front doors and allowed a lady passenger in the front seat with the driver to always be able to step out upon the curb, and not be compelled to walk around the car in order to get to the sidewalk.

As the conversation progressed the prospect was unconsciously being sold a car, and was led up to the point where HE HIMSELF asked for a demonstration, with the result that the ENTIRE FAMILY AS A UNIT bought the car.

The salesman sold the car without the prospect realizing that he was being forced to buy. THE MAIN THING IS TO ALLOW THE PROSPECT TO THINK HE IS BUYING THE CAR, WHILE IN REALITY YOU ARE SELLING IT TO HIM.

The moral of all this is, that no matter how good your car may be, it cannot possibly sell itself alone. This is just an example of one type of buyers—the man who has owned a car and who goes "shopping" when he buys.

Know Your Man before You Try to Sell Him.

By using a little tact, any dealer can ascertain the purpose to which the prospect intends to put the car be buys—whether or not it is for family use, personal pleasure, cross-country touring or for business purposes.

Experience in selling motor cars, teaches that all prospective buyers may be separated into five main classes:

(A) Price tag—the man who is looking for a bargain regardless of the age and often regardless of the condition of the car—just so that he gets a car that will run.

A second-hand car or any old car will do.

This class of buyers are limited usually to the "wage earners," who hesitates between a motorcycle and a second-hand motor car. Before wasting any time on him, FIND OUT HOW MUCH REAL MONEY HE HAS to invest and unless he has cash on hand, pass him up, courteously but quickly. REMEMBER YOUR TIME IS VALUABLE—YOUR EXPENSES ARE GOING ON WHILE YOU ARE TALKING TO HIM.

(B) Second hand fiend—this man is a shrewd buyer, he is the David Harum of the automobile business, usually with little money AND TRYING TO UNLOAD ON TO YOU. In the first place he bought a much-used second-hand car. Then he invested a little more money and traded it with a friend for a better car, hoping that he could unload his new purchase on you by paying a small amount of cash and getting a brand new, up-to-date model.

Don't let your desire to move a car from the salesroom to the street, lead you into an unbusinesslike transaction. Just remember that the second-hand car may prove a "white elephant" on your hands. (It costs just about as much money to keep capital tied up in a second-hand unsalable car, as it would to feed and care for an elephant.)

Rather than do this, LET HIM GO. CONCENTRATE YOUR TIME AND ENERGY UPON THE MAN WHO HAS CASH IN THE BANK. It is just as much to know where not to work as to where to work.

There are exceptional cases, however, especially where a man owns a car that YOU sold him and who wants to buy a new model from YOU.

Tack this up on the wall, over your desk: "A certified check in your bank book ready for deposit, is worth more than a second-hand car on the floor."

(C) Appearance and pleasure—this man is influenced largely by the lines of the car and the anticipation of the pleasure he is going to get out of it. He is usually in a hurry to buy. He belongs to that rapidly disappearing class that used to walk in and buy a car in ten minutes. It does not require a salesman to sell this man. But the wise, hard-headed, shrewd dealer with a view to his permanent success, will analyze this man's requirements and sell him the car best fitted to his needs, so that the sale will not act as a boomerang.

(D) Social prestige and reputation—this is the man who usually buys a car to please his wife with social aspirations. She knows absolutely nothing about a car, but has received the impression some way that "to be anybody" she must have a name-plate with an artificial value, rather than a car of merit. How have you been handling this class of buyers?

A thorough analysis of sales made by successful dealers, proves that this prospect if handled right, is always easy to sell. The approach in this case is through the man of the house who realizes that $5,000 is 5 per cent of $100,000, and when shown point for point that a car selling for $2,750 will give as good or better service, with accompanying elegance and atmosphere of refinement, he will not WASTE two or three thousand dollars on some fancy of his household.

No matter how much money this man is worth, he is NOT willing to waste two or three thousand dollars on a nameplate. YOU AS A DEALER, WILL SELL MORE CARS AND MAKE MORE MONEY BY GIVING YOUR CUSTOMERS REAL VALUE.

(E) Service and business—this man represents the LARGE majority of buyers today. HE IS MOTOR-EDUCATED. He has probably owned a car before or else has made a very thorough study of motor car construction and is taking the advice of friends and benefiting by their experience. While this man is open to reason, he is not going to buy in a hurry.

Before deciding he will get underneath the paint and the hood. Your first move is to as tactfully as possible ascertain if influence is being brought to bear upon him in favor of a particular car by some neighbor or friend. Then you will know what cars you are in competition with and what bias and prejudices you will have to overcome before you can make the sale.

Probably the neighbor or friend of this prospective buyer owns a car that is not up-to-date, although it is apparently giving good service. AND RIGHT HERE IS WHERE YOUR SALESMANSHIP IS TESTED.

Prove to this prospective buyer that the car **ou** are selling with left-side drive and center **ntrol** (for example) is a year or more ahead of **her** cars, as a consequence next year it will **ill** be up-to-date and will also demand a much **igher** second-hand value, taking it for granted, **course**, that you are able point for point, to **ow** where your car will give as great or better **ervice** than the car owned by the neighbor or **iend** of your customer.

All buyers—the majority of buyers are influ-**nced** greatly by printers' ink. They have more **r less** definite opinions of various cars, formed **y what** have read about them. Therefore, as a **und**amental principle, YOU SHOULD NOT RISK **OUR** TIME NOR MONEY ON AN UNKNOWN **AR.** A car, whose name is a household word, **s naturally** much easier to sell than a car that **he** prospective buyer never heard of before. THE **WELL** ADVERTISED AND TESTED CAR **MEANS** QUICKER AND MORE FREQUENT **SALES.** Especially is this true with a car that has demonstrated its superiority in public contest, such as races. Remember, A QUICK SALE IS MORE PROFITABLE THAN A SLOW SALE.

The modern automobile dealer, is the man who is equipped to TAKE CARE of his customers, especially if the buyer intends to drive the car himself. In fact, most every up-to-date dealer now has an efficient **service** department.

A little service and assistance gives the owner the feeling of confidence and GOOD WILL toward both you and the car. Service means satisfied customers, and satisfied customers means a permanent, profitable business for you. Service also converts probable knockers into positive boosters. If your success is to be lasting every man to whom you sell a car must, one year or more from date of sale, be as enthusiastic as the day in which he bought the car from you. This is possible by first giving real value and second by taking care of him. (from booklet published by National Motor Vehicle Co.)

*Advantages and Disadvantages.

If You are Selling a Car Understand Its Features.

The auto salesman must be able to talk on almost any subject relative to the construction of various cars. He must know the advantage and disadvantages of the features of different cars which will be suggested by a prospective **customer.** For instance, if the salesman is selling a **car** with a four-point suspension, he must know **the** advantage of the four-point suspension and **the** disadvantage of the three-point and vice versa.

A few subjects will be treated in the **following** matter. For further information I would **suggest** that every auto salesman make it a point **to** accumulate the catalogs of all motor car **manufacturers**, and in this way he will see the **different** features discussed by the various **manufacturers** and will gain many valuable pointers.

Long Stroke vs. Short Stroke.

The advantages of the long-stroke over the short-stroke type of engine are:

Leverage. Given a certain expansion force within the cylinder, the travel of the piston being longer, and transmitted to a longer crank, it operates on a longer lever.

Greater expansion. Given a charge of a certain volume at the time of ignition, it will expand to a greater volume (before the opening of the exhaust valve) in a long-stroke engine than in a short-stroke one, thereby using more of the energy generated in the expansion of the gases. The theoretical idea of any heat engine is to use as nearly 100 per cent of the expansion of the charge within the engine as is possible. This accounts for the greater efficiency of the compound steam engine over that of the single-acting type. This type of engine is substantially an elongated-stroke engine, the only difference being that the low pressure portion of the stroke is in a larger cylinder than the high-pressure portion. In the long-stroke engine, this super-expansion takes place in a less degree in the same cylinder, so that at the beginning of the stroke the cylinder is a high-pressure cylinder, and at the lower portion of the stroke, it is a low pressure one.

It has been found in high speed express locomotive practice, that the short-stroke single-expansion engine, while it produces a very low rate of efficiency and is enormously wasteful, the actual results in high-speed, light-draught work are superior to those of the more efficient type, as only the very cream of the expansive energy is used. This has been found to apply in the same way to gas engines, and for racing work, the short-stroke, while less efficient, more wasteful of fuel, and less flexible, has been found to give better results than the long-stroke type. This is the reason some of the prominent European makers produce stock cars with small bores and long strokes, while their high-speed cars are the reverse. Road racers, on the other hand, generally revert to the preponderance of stroke again, as the short-stroke type is not sufficiently flexible to produce good reults, unless built in enormously large power-units.

This was well illustrated in a recent automobile road race; where even the high horsepower cars were found to have a preponderance of stroke, while the lighter ones were all designed with long strokes. One **make, whose sprint cars, designed for excessive speed for short distances—below 150 miles—have larger bores than strokes; while** those designed **for the long-distance high-speed grinds, have longer strokes than bores.**

Slower crank shaft speed for the same piston speed: It has been found that speed in revolution per minute is not an accurate standard by which to gauge the power of an engine; but that piston speed in feet per minute, in combination with bore and number of cylinders, is the true measure of an engine's power. It is thus seen that two engines of the same design except as to stroke, will give the same power, (disregarding considerations of expansive efficiency) at equal piston speeds. But the long-stroke engine in reaching the same piston speed as the short-stroke type, will revolve much slower. The advantages of slower speed are, of course, well understood. If compared to crank shaft speed, the long-stroke type will give greater power, less speed, less friction.

There are other advantages, but the above are among the most important. In considering them, it must be remembered that the comparison is made in the light of efficiency, which is under stood to be made up of the factors; horsepower per gallon of gasoline, horsepower per pound of weight, horsepower per cubic foot of space occupied, durability and flexibility. In a racing motor, this term would not have the same meaning, nor would all racing motors come under the same category, as explained above.

Advantage of short-stroke engines are higher speed with smaller pistons, therefore less wall pressure and less liability of ring leakage.

There is less exposure of metallic surface less movement of the piston and less angularity, that is to say, as the crank is relatively short, the connecting rod is thrown less out of its perpendicular position and therefore the piston is less violently pressed against the walls of the cylinder, with the result that there is a saving in frictional loss which is one of the greatest troubles we have to contend with, in striving for higher efficiency. Another point is, that with a short stroke it is possible to have piston pin higher up, this preventing the tendency of piston to chatter which it does when pin is too near the lower end.

Five-Bearing Crank Shaft.

Is a five-bearing crank shaft more efficient and durable than the three-bearing type? Is there less liability of loose bearings in the five bearing than in the three? Is it not true that it is usually the connecting rod bearings and not the crank shaft bearings that wear first and therefore the number of crank shaft bearings has nothing to do with this trouble?

Ans.—There are advantages on both sides of the engine journal question. The advantages of the five-bearing type rest on the fact that there is a longer bearing surface, hence more provision for wear and (more work in fitting the bearings when worn.)

---

*See page 255 for Advantages and Disadvantages of different Ignition Systems.

The following are the advantages and disadvantages of the three and five-bearing crank shaft as given by the Continental Engine Co. and the Rutenber Engine Co.:

The subject is one that is open to much discussion and for 4-inch bore and less, the three bearings are undoubtedly an advantage over the five on account of the simplicity, and yet the distance between supports is sufficiently small to overcome the vibration set up in high speed running.

On larger sizes, if the crank shaft is made sufficiently strong and the bearings of ample width, the three-bearing engine, as has been shown, is very satisfactory, but in these sizes it is an advantage to have light weight and yet stability, and in consequence, the five bearings often prove better in the argument that they can get their surface without heavy crank shafts and yet be sure against vibrations.

The advantages of the three-bearing crank are as follows: An engine so equipped is slightly cheaper to build, easier to scrape bearings in and a slightly shorter engine can be designed by using the three-bearing shaft.

The disadvantages are: The wear is slightly greater at higher speeds, and to obtain same strength as a five-bearing shaft it requires larger diameter bearings, hence higher peripheral speed.

The advantages of the five-bearing shaft are: Less distortion and less wear at high speeds only; and less heat, that is; if properly fitted.

The disadvantages of the five-bearing shaft are: The initial cost in machining and fitting. Would, however, recommend the three-bearing job for commercial purposes.

Offset Cylinders.

See page 81 also fig. 5, page 82 advantages are: Less liability of back kick, reduced wear on bearing surfaces of cylinder walls, connecting rods and crank shaft, less liability of the engine to stall when car is running slowly on high gear.

Four vs. Six Cylinders.

The advantages of the eight over the four or six is in flexibility of control, and lapping of power strokes,* consequently much simpler in points of both operation and repair; more power is in a given space, especially as regards length; the weights on account of heavy fly wheel in the four will be approximately the same; better facilities for uniform distribution of the gas to the various cylinders; more rigid crank shaft.

The advantages of the six cylinder over the four are: Flexibility of operation due to continuous torque, allowing a greater range of speed without resort to gear shifting; greater power at low speed of engine; as, for instance, in hill climbing; due to the lapping of power strokes, less vibratory strain on the gearing in the transmission and differential drive and pinions as well as the universal joints and to some extent the tires on rear wheels. (See pages 128 and 126.)

Advantage of the four cylinder—principally economy and less number of parts.

Advantages of the T-Head Cylinder.

The principal advantage of the T-head motor over the L-head is that the valve area is larger than with the L-head with the valves side-by-side (see page 81 for comparison.) Another advantage is that the gas has a direct passage from one side of the engine to the other, and the plugs, situated in the inlet valve pocket, are not subjected to a carbon-laden blast of burned gas at the exhaust. The exhaust is more complete, as the outward passage at one side can be accelerated by the inward rush of fresh gas.

The disadvantages are that the volume of the valve-pockets is increased, thus providing more space for burned gases to lurk in than with the L-head, and that the engine so constructed requires two cam shafts and with their gears, bearings and casings, are heavier, for the same power, and much more expensive to manufacture.

The "L" head is easier to construct and requires less parts and if properly designed so gas pockets over valves is correct and val properly timed—it is more suitable for tour and general work. See index for "compressi for explanation of valve pocket.

The overhead valve engine is more powerf and efficient owing to the relative position valve to combustion chamber. The valves h ever, are usually noiser and the compression ally higher and very hard on spark plugs— index for "spark plugs," "valves" and "c pression" which will treat on overhead val advantages and disadvantages.

The Eight Cylinder Engine.

The advantages of the eight over the four six is clearly brought out in text on pages 1 and 127. Better balance, more firing impuls and torque are the chief advantages.

Advantages: Greater power for a given weig than the six-cylinder design.

Eight cams instead of 12, and also shorter camshaft.

Engine is considerably shorter than six-cylinder models.

Shorter and lighter crankshaft.

Shorter and lighter crankcase.

Uniformity of torque, which is better than th of six-cylinder engine.

Suitability of design for reasonably high compression.

High mechanical efficiency.

Disadvantages: Further complication owing t more cylinders to care for.

Cost of and difficulty in manufacturing special design of connecting rods.

Reduction in area of big-end bearings.

Extra weight of cylinder block in ratio t power, as compared with the four-cylinder o six cylinder design.

Requires better design and more careful workmanship.

Balanced Crankshaft.

A balanced crankshaft will make a good engine run smoother at high speeds, but a properly designed engine will run at high enough speeds with no additional benefit from an abnormal shaft, and no system of balancing can increase power except at quite high speeds.

If an engine has an essentially weak shaft the whipping of that shaft at high speeds places stresses on the bearings and causes power to be wasted in friction. By balancing the shaft we may stop the whipping and so raise the power, but this is only a side issue; the real value of a balanced shaft is the greater smoothness of the engine at the highest speeds the owner is likely to use, see pages 78 and 122.

The Floating Axle.

The advantages of a full floating axle over a semi-floating axle are, that whereas in the semi-floating type of axle the wheels are secured rigidly to the drive axle and are supported on bearings between the latter and the axle tube, the drive axles of the floating axle are flexibly clutched to the wheels, run on separate bearings and carry no weight. The semi-floating drive axle must not only transmit the driving torque, but must support the wheels besides, while the floating drive axles receive tortional strains only (the weight of the car being carried by the axle housing). The bearings on which the wheels of a floating axle are mounted are outside of the axle tubes, and easily accessible, while those of the semi-floating axle are between the drive-axles and the tube, and hence are not as accessible. The drive-axles on a floating axle may be removed permitting the differential to be taken out without disturbing the wheels or their mountings. This is, of course, impossible with a semi-floating axle, as in this type the housing must be entirely removed from the car, together with the wheels, axle and differential.

The expense of manufacture of a semi-floating axle, however, is much less than that of the floating type, and as they have given satisfactory service where they have been properly designed many manufacturers do not deem the greate cost of the floating type warranted. For this reason, in late years, a compromise type has been evolved, known as the three-quarter floating type, which possesses some of the advantages of both. (Write Timken Axle Co., Detroit, Mich., for description of their axles) see page 38, also charts 272 and 272A.

---

*See page 126.

Three-Point Suspension.

Three-point suspension is a general term that refers to the suspension of the power plant by three points, and has several applications to motor car design. The commonest of these is the three-point support of the engine, and three-point suspension of the frame. When three-point suspension is specified as a separate feature, it is understood as referring to the frame suspension. When it is included in the description of the engine it refers to the engine. (See page 11 and 72.)

The advantages advanced for three-point suspension are as follows: An engine mounted to the frame by three points is not subjected to any strains upon the warping of the frame. The jarring from the road is less severe on a three-point suspended frame, because at the end at which it is suspended by one point, lateral motion of the axle has very little effect upon the frame, so that in going over a bump on one side of the road it is seriously felt but once, although both axles are deflected by it. Three-point suspension permits of flexibility of the frame without loss of strength, thereby saving weight, as it requires greater strength to support a load rigidly, than it does flexibly.

Many prominent motor car designers are adherents to the four-point form of engine support, not from any objection to the three-point principle, but because in practice the four-point support has been found satisfactory.

The Packard for many years used a four-point engine support on its four cylinder cars, but found it advantageous in the longer six cylinder engines to use the more flexible form of suspension, viz.; the three-point.

*A Few Words to the Young Man Just Starting.

There is an old saying to the effect, "All the world loves a lover." There's another one, just as true, to the effect that " all the world loves an OPTIMIST."

It pays to be optimistic! "Be pleasant every morning until 10'clock, and the rest of the day will take care of itself."

Optimism is its own reward. Be pleasant and courteous at all times regardless of the kind of a reception you receive and in nine cases out of ten the coldest turndown will develop into a warm welcome if you exercise the proper amount of diplomacy and tact in approaching even the most irritable prospect. Even if you don't succeed in securing encouragement on your first call, you leave behind you a favorable impression which will be working in your interest and will do a whole lot towards landing the order for you on your second visit.

Every day of course, cannot be a record day in selling cars. We all have what seen to be our unlucky days, and you may occasionally have the same experience, but the very next day may develop into your record breaker, and more than offset the poor results of the preceding day.

It is the general average which counts. You may have what seems to be two or three very unlucky days in one week and all of the other days may so far exceed the result of the unlucky days that the average of the week will be up to your high water mark. Every business man will tell you that he has days and weeks when it seems that "the bottom has dropped out of business," but yet at the end of the month or the end of the year they find the general average is very satisfactory after all.

That's the way you'll find it in all lines of work. You will very seldom find real cause for discouragement, and all of these expereinces in overcoming difficulties, and making the good days offset the bad days, is the sort of EXPERIENCE that will be of great value to you in your future work along any line.

Some of our readers, who are now among the greatest producers, had what seemed to be more than their share of unlucky days at the start. Some of them wrote us at the end of the first week that they didn't believe they could ever make a success of the work and they were on the point of giving up in disgust. They didn't give up, however. They "stayed with the ship." They started the second week with renewed determination to succeed. And they DID succeed. They found that determination and persistency were the qualities that always WIN—just as they will win for YOU.

As previously stated, the first essential is to know your car. Be prepared to intelligently present your proposition and know how to overcome any objection when it is presented. Be convinced, in your own mind, that you have a proposition which justifies the very best effort you are capable of putting forth. Sell to YOURSELF first— then you'll find it an easy proposition to sell to others, and above all else, do not forget for one moment that you are the representative of the greatest industry the world has ever known.

Where to Obtain Further Information or Catalogues.

Automobiles; write to one of the auto magazines (see page 529), and see also automobile manufacturers addresses—below.

Ignition; for catalogues on ignition, see ignition subject and page 288.

Electric starter, etc.—see page 373.

Carburetors; see page 162, for address of manufacturers.

Where to obtain parts of cars no longer manufactured—see page 547.

By addressing the publisher of this book; addressing your correspondence to A. L. Dyke, Publisher, St. Louis, Mo., "Information Department," and enclosing stamped and self-addressed envelope for reply, we will gladly furnish you with any information we can. At certain seasons of the year, inquiries of this nature are very numerous but we answer just as soon as we can.

Specifications of leading cars—see charts 229 to 232.

Addresses of some of the Leading Automobile Manufacturers.

Abbott-Detroit Motor Car Co., Detroit, Mich.
Apperson Motor Car Co., Kokomo, Ind.
Auburn Motor Car Co., Auburn, Ind.
Briscoe Motor Car Co., Jackson, Mich.
Buick Motor Car Co., Flint, Mich.
Cadillac Motor Car Co., Detroit, Mich.
Case Motor Car Co., Racine, Wisc.
Chalmers Motor Car Co., Detroit, Mich.
Chandler Motor Car Co., Indianopilis, Ind.
Cole Motor Car Co., Indianapolis, Ind.
Dodge Motor Car Co., Detroit, Mich.
Dort Motor Car Co., Flint, Mich.
Empire Motor Car Co., Indianpolis, Ind.
Ford Motor Car Co., Detroit, Mich.
Franklin Motor Car Co., Syracuse, N. Y.
Hudson Motor Car Co., Detroit, Mich.
Hupmobile Motor Car Co., Detroit, Mich.
Jackson Motor Car Co., Jackson, Mich.
Jeffery Motor Car Co., Kenosha, Wisc.
King Motor Car Co., Detroit, Mich.
Mercer Motor Car Co., Trenton, N. J.
Mets Motor Car Co., Waltham, Mass.
Mitchell Motor Car Co., Racine, Wisc.
National Motor Car Co., Indianapolis, Ind.
Oakland Motor Car Co., Pontiac, Mich.
Oldsmobile Motor Car Co., Lansing, Mich.
Overland Motor Car Co., Toledo, Ohio.
Packard Motor Car Co., Detroit, Mich.
Peerless Motor Car Co., Cleveland, Ohio.
Pierce-Arrow Motor Car Co., Buffalo, N. Y.
Regal Motor Car Co., Detroit, Mich.
Scripps-Booth Motor Car Co., Detroit, Mich.
Stearns-Knight Motor Car Co., Cleveland, Ohio.
Studebaker Motor Car Co., Detroit, Mich.
Stutz Motor Car Co., Indianapolis, Ind.
Velie Motor Car Co., Moline, Ill.
Westcott Motor Car Co., Richmond, Ind.
Willys-Knight Motor Car Co., Toledo, Ohio.
Winton Motor Car Co., Cleveland, Ohio.

---

*See Instruction 44.

**The S. A. E. Horsepower Formula.

The horsepower of a gasoline engine is dependent upon the following things: number of cylinders, area of piston heads, average number of pounds per square inch exerted upon the piston during the working strokes, and the revolution per minute of the engine.

S. A. E. means Society of Automotive Engineers. This formula was orignally adopted by the A. L. A. M. (American Licensed Automobile Manufacturers) and later by the S. A. E.

It has been worked out upon the assumption that the piston speed is 1000 ft. per min. and that the mean effective pressure is 90 lb. per sq. in. Inasmuch as the piston speeds of modern engines run up as high as 1500 to 2000 ft. per min., and the mean effective pressures per sq. in. go up to 110 to 125 lb., you can see that this formula is not altogether accurate, as to the actual horse power would be considerably more, however it is used for estimating and serves its purpose.

In order to compensate for the inferior quality of gasoline, some manufacturers have reduced the area of the combustion chamber so as to give a high compression.

S. A. E. Horsepower Table.

$$H.\ P. = \frac{(\text{DIAM. IN INCHES})^2 \times \text{NUMBER OF CYLINDERS}}{2.5}$$

BORE		HORSE POWER			
INCHES	MILLIMETERS	1 CYLINDER	2 CYLINDERS	4 CYLINDERS	6 CYLINDERS
2½	64	2.5	5.0	10.0	15.0
⅝	68	2.8	5.5	11.0	16.5
¾	70	3.0	6.0	12.1	18.1
⅞	73	3.3	6.6	13.2	19.8
3—	76	3.6	7.2	14.4	21.6
⅛	79	3.9	7.8	15.6	23.4
¼	83	4.2	8.4	16.9	25.3
⅜	85	4.6	9.1	18.2	27.3
3½	89	4.9	9.8	19.6	29.4
⅝	92	5.3	10.5	21.0	31.5
¾	95	5.6	11.2	22.5	33.7
⅞	99	6.0	12.0	24.0	36.0
4—	102	6.4	12.8	25.6	38.4
⅛	105	6.8	13.6	27.2	40.8
¼	108	7.2	14.4	28.9	43.3
⅜	111	7.7	15.3	30.6	45.9
4½	114	8.1	16.2	32.4	48 6
⅝	118	8.6	17.1	34.2	51.4
¾	121	9.0	18.0	36.1	54.2
⅞	124	9.5	19.0	38.0	57.0
5—	127	10.0	20.0	40.0	60.0
⅛	130	10.5	21.0	42.0	63.0
¼	133	11.0	22.0	44.1	66.1
⅜	137	11.6	23.1	46.2	69.3
5½	140	12.1	24.2	48.4	72.6
⅝	143	12.7	25.3	50.6	75.9
¾	146	13.2	26.4	52.9	79.3
⅞	149	13.8	27.6	55.2	82.8
6—	152	14.4	28.8	57.6	86.4

S. A. E. Horsepower Table for 4, 6, 8 and 12 Cylinder Engines.

Bore in inches	Number of Cylinders — Four	Six	Eight	Twelve
2½	10.00	15.00	20.00	30.00
2⅝	11.23	16.85	22.46	33.70
2¾	12.08	18.13	24.16	36.23
2⅞	13.37	20.00	26.74	40.00
3	14.40	21.60	28.80	43.20
3⅛	15.64	23.50	31.28	47.00
3¼	16.92	25.39	33.84	50.78
3⅜	18.21	27.30	36.42	54.60
3½	19.61	29.45	39.22	58.90
3⅝	21.08	31.57	42.16	63.14
3¾	22.50	33.75	45.00	67.50
3⅞	24.22	36.32	48.44	72.64
4	25.60	38.40	51.20	76.80
4⅛	27.20	40.80	54.40	81.60
4¼	29.00	43.50	58.00	87.00
4⅜	30.65	46.00	61.30	92.00
4½	32.40	48.60	64.80	97.20
4⅝	34.28	51.41	69.56	102.81
4¾	36.15	54.20	72.30	108.40
4⅞	38.25	57.21	76.50	114.42
5	10.00	60.00	80.00	120.00
5⅛	42.20	63.20	84.40	126.40
5¼	.44.20	66.40	88.40	132.80
5⅜	46.34	69.50	92.68	139.00
5½	48.48	72.72	96.96	145.44
5⅝	50.80	76.10	101.60	152.20
5¾	53.00	79.50	106.00	159.00
5⅞	55.28	83.88	110.56	167.76
6	57.70	86.64	115.40	173.28

*Piston Speed.

When this S. A. E. formula was first adopted most engines developed their horse power at 1000 feet of piston travel per minute. Therefore it was worked out under the assumption that the piston speed is 1000 feet per minute.

The factor of piston speed takes in both the length of the stroke and speed of the crank-shaft in rev. per min. and mean effective pressure of 90 lb. to the square inch.

The shorter the crank the quicker it can be turned. the longer the crank, more piston travel per stroke, therefore crank can travel slower and still the piston will travel the required distance.

As an example; suppose the stroke of an engine is 4 inches it would have to make 3 strokes to travel 12 inches or 1 foot, because each stroke is 4 inches in length. Take on the other hand, an engine with a stroke of 6 inches; it would have but 2 strokes to make per 12 inches or 1 foot of travel. Therefore it is evident from the above that the shorter the stroke, the faster crank must move to cause piston to travel 1000 feet in the specified time.

A given amount of power can be developed in cylinders of either large or small diameter. Thus there is the example of the stationary gas engine. To obtain for example, 10 h. p. from this type of engine a very large cylinder and comparatively slow speed would be employed with a maximum speed of perhaps 300 to 600 r. p. m. A modern 10 h. p. automobile engine on the other hand has four very small cylinders, but a high speed say, 1500 to 2000 revolutions per minute. The individual power impulses are very much weaker than those of the large slow speed engine, and consequently its parts can be made much lighter and smaller, as the shocks and stresses that have to be sustained are proportionately much less.

How To Figure The S. A. E. Formula.

This formula is used by all leading manufacturers and by the license offices in different cities.

$$H.\ P. = \frac{D^2 N}{2.5}.$$

For example: What is the estimated formula h. p. of a four cylinder engine which has a 4 inch stroke?

By referring to the table, to the left, one 4 in. bore cylinder is 6.4 and 4 cylinders of 4 in. bore is 25.6 h. p. This is arrived at as follows:

D^2 (diameter squared) $4 \times 4 = 16.$

N (number of cylinders) $16 \times 4 = 64.$

2.5 (constant) $64 \div 2.5 = 25.6$ h. p.

It will be noted that the stroke of the cylinder was not taken into consideration at all.

Another Formula (not the S. A. E.).

The following formula takes into consideration the stroke as well as the bore and also the speed.

$$\text{H. P. Formula: } \frac{D^2 \times N \times L \times R}{C} = \text{H. P.}$$

This means square the diameter or bore of the cylinder (D^2) and multiply the result by the number of cylinders (N) and multiply this result by the length of stroke (L) and multiply this result by the revolutions (R) per minute of crank shaft, then divide this total result by the "constant" (C) below.

The "constant" for 4 cycle engine is 13,000.
The "constant" for 2 cycle engine is 10,000.

Example; suppose we have a 4 cylinder engine—4 inch bore (diameter) and five inch stroke and 1000 revolutions per minute—what is the horse power?

4 x 4 equals 16 (squaring the diameter D^2).
16 x 4 equals 64 (result multiplied by number of cylinders "N").
64 x 5 equals 320 (result multiplied by length of stroke "L").
320 x 1000 equals 320000 (result multiplied by number of revolutions "R").
320000 divided by the "constant," 13,000 will give us 24.6 h. p. for a 4 cycle engine.
320000 divided by 10,000 will give us 32 h. p. for a 2 cycle engine.

The "constant" is a figure arrived at by the founder of the formula. You will note there is a difference of 1 h. p. between the horse power figured with this formula and the S. A. E. formula. There is usually a difference with all formulas.

IART NO. 224—Horse Power Formulas. *See page 540 for table of piston travel in feet per min.

**—known as the N. A. C. C. (National Automobile Chamber of Commerce) formula.

INSTRUCTION No. 40.

HORSE POWER, TABLES AND GENERAL DATA. Specifications of Leading Cars. Standard Adjustments of Leading Cars. Piston Displacement. Conversion Tables; Degrees, Millimeter and Thousandths of an Inch. Dynamometer Test. S. A. E. Horse Power Formula. Brake Horse Power with Prony Brake. How to Find Gradient. Where to obtain Parts of Cars No Longer Manufactured.

*Horse Power.

The power unit used in motor work is a standard rate of doing mechanical work, equal to 33,000 pounds (or weight) raised through a height of 1 foot in 1 minute; or if we move 16,500 lb. through 2 feet or any proportionate ratio which multiplied together equals 33,000 in the same time, it is also equal to working at the rate of 1 horse power. This means that, theoretically, if the speed of a motor car engine could always be kept constant, and thus be giving uniform power, this power could be utilized to move any load up any gradient by taking a proportionately longer time to do it, providing that the car had a perfect all-speed gear. This principle is, as far as necessary realized by the change speed gear of a car which gives a range of three or four speeds. Wind resistance increases in proportion to the "square" of the speed: thus at 20 miles per hour it is four times what it is at 10 miles, and at 30 miles per hour nine times, and so on.

Horsepower Abbreviations.

Horsepower.—This nowadays has nothing to do whatever with the power developed by a horse—but is an unscientific way of defining power. In the days of Watt and other early engineers (of the 18th century) the work in ft. lbs. capable of being done by an average draught horse was taken as the unit of work. A motor rated at 1 horsepower is capable of doing 1 mechanical unit of work, which is equal to the power expended in lifting a weight of 33,000 lbs. through a height of 1 foot in 1 minute of time. The French horsepower equals 32,549 foot pounds, and is thus less than the English standard.

"Brake" horsepower (abbrev. B.H.P.) is the power available at the driving shaft of the engine, such as could be determined by making a power absorption test by means of a brake type of dynamometer.

"Actual" Horsepower is the amount of power that would be available if there were none absorbed by friction within the engine itself, and the total energy of the explosion was transmitted without friction or other losses to the road wheels.

"Indicated" horsepower (abbrev. I.H.P.) is measured by taking an indicator diagram, which shows the "mean effective pressure" of the explosion, in pounds per square inch. For high speed engines an optical device is used, which plots out the pressure line on a photographic plate. From this the mean effective pressure during the stroke can be calculated.

Thermal efficiency of an engine equals the number of British thermal units, converted into work, divided by the total heat.

Total power of an engine is the same as its I.H.P.: If an engine develops on brake tests, seven brake horsepower, or actual horsepower, and it takes 3 H. P. to drive itself, it is therefore properly called a ten indicated and seven actual or brake horsepower engine.

Horsepower is an art which had its inception with the steam engine, and since then has been going through a phenomenal process of evolution. Horsepower, today, according to the manufacturer's catalog, is one of the vaguest quantities; and according to the best accepted formula it is almost as uncertain.

To the person whose conception of horsepower is limited to raising 33,000 pounds 1 foot in 1 minute the catalog rating of 50 to 70 horsepower has little value or meaning. From this however, it will readily be seen that horsepower means so much work accomplished in a certain length of time.

How to Calculate Horsepower.

To calculate exactly the horsepower of a gasoline automobile engine is, of course, almost impossible. No matter what the formula used, there must be some trifling error, depending upon, if nothing else, the number of revolutions made per minute by the engine. Probably the only way of learning the exact horsepower of any engine is by actual test upon a mechanical machine (as per charts 224A and 225).

It is possible, however, to estimate the horsepower of any engine within a reasonable degree of accuracy. Of the several formulas promulgated for this purpose, the one now used to the greatest extent in the United States is the A. L. A. M. formula, now known as the S. A. E.

---

*See also page 596.

Gasoline Engine Horse Power Defined.

A gasoline engine depends upon speed for production of useful work, a gasoline engine which would develop a certain horse power at 750 r. p. m., would develop, roughly, double that at 1500 r. p. m. if suitably designed.

The reason for this is that the driving effort of the exploding gases is tolerably constant through a long range of speeds. In this respect it is absolutely different from either the steam or electric motor. Each of these exert their greatest driving effort at low speeds, and fall away—relatively, of course—as the revolutions mount up, due in the case of steam to insufficient mobility and rate of expansion, and in the case of electricity to a progressive lag in the rate of saturation as the speed increases.

With each of these motive powers the actual turning moment or energy is very great comparative to engine speed when starting up, hence their eminent suitability for locomotion, change speed gears being unnecessary.

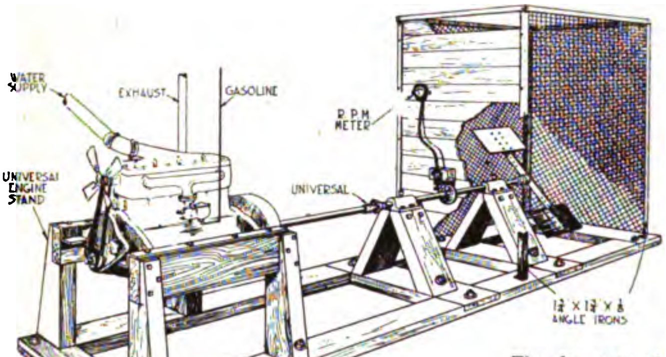
With the gasoline engine, on the contrary, the turning moment is not great at any time, relative to its speed but is roughly proportional to it. Consequently, we are within certain wide limits dependent entirely upon engine revolutions for power.

It is for this reason that transmission gears are necessary, namely, to keep the engine speed up, for starting, or hill-climbing.

In mentioning the nominal horse-power of an engine, i. e., the catalogued h. p., it is intended to convey that the engine develops this power at a moderate touring speed. An ordinary so-called 15 h. p. engine, for example, will probably develop that power at somewhere between 1000 and 1500 r. p. m.

This by no means indicates its maximum, however, for there is more than one engine of 3½ in. bore (19.6 h.p.) which will develop over 30 h.p. —at of course, a very high speed. Needless to say, this is quite an exceptional figure, but it serves to illustrate the principle.

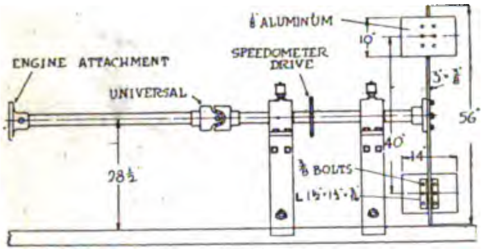
The Fan Dynamometer.



Consists of a fan, driven by engine. The power required to turn the fan increases with the speed and at all times bears a definite relation to the speed. Hence, knowing the speed it is possible to determine the horse power being developed—see r. p. m. (revolutions per minute) and h. p. table below.

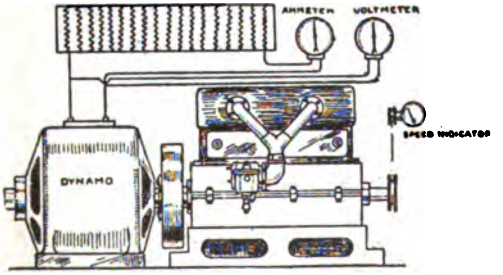
The speed is shown by means of a speedometer, driven from the fan-shaft, but registering revolutions per minute instead of miles per hour.

Engine is bolted to a frame. The drive shaft is shown. The fan shaft is carried on two heavy pillow blocks bolted to wooden supports with ball or roller type bearings if possible. The fan arm should be of solid bar nickel steel 3x⅜" by 5/16" long. The hub should also be of nickel steel. **Fan blades** are heavy sheet aluminum, placed 40 in. apart on centers, and bolted to the fan arm by means of angle iron strips that are riveted back to back on the aluminum blades. To avoid accident the fan is enclosed in a cage of mesh wire netting.



R.P.M.	H.P.
400	1
600	2½
800	6
1000	12
1200	20
1300	25
1400	37
1500	40
1600	48
1700	60
1800	70

Electrical Dynamometer.

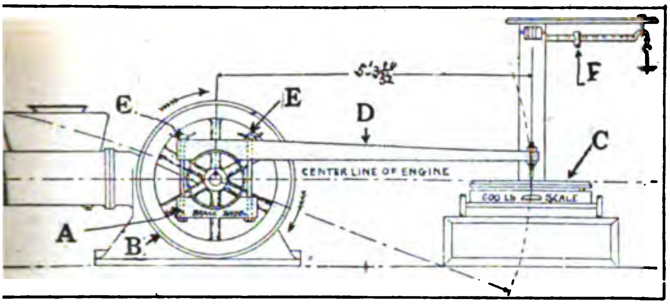


The method for testing the h. p. of a gasoline engine with an electrical dynamometer is as follows:—The engine is belted or (preferably) coupled direct to a dynamo machine. Connected up with the dynamo are two specially accurate electrical measuring instruments, one a voltmeter and the other an amperemeter. The current which the dynamo produces when driven is used up by either a group of lamps or a set of wire or liquid resistances. The amount of work the dynamo will do, such as lighting lamps, etc., depends on the power put into it from the engine. **It is easy to convert electrical power units into mechanical units. Thus:** amperes x volts equals watts, and there are 746 watts to a horsepower, so that by simply taking the readings of the voltmeter and ammeter the amount of power the dynamo is giving out is at once calculated. The dynamo, of course, does not transform the whole of the power put into it into electricity, but it may transform somewhere near 90 per cent of it. Certain mechanical and electrical losses occur in the dynamo, but these are calculated beforehand. Hence, knowing exactly how much of the power, put into the dynamo is lost or wasted and the maximum amount given out, will give the power actually produced by the engine.

CHART NO. 224A—Gasoline Engine Horse Power. The Fan Dynamometer. Electrical Dynamometer.

*Fan Dynamometer from Motor World by Mr. S. T. Williams (used by Reo Service Stations).

Prony Brake H. P. Test.



One horse-power is defined as the power that will raise 550 lb. 1 ft. high in 1 sec., or, as the case may be, 33,000 lb. 1 ft. high in 1 min. The power that will do one will exactly do the other if the gearing is suitably arranged.

Construction; (B) flywheel revolving in a clockwise direction as per arrow.

(A) wooden clamp, provided with tightening screws (E) and extended into arm (D), whose outer end bears on platform of scale.

Example; assume now that we want to find the h. p. at, say, 1500 r. p. m., we start up the engine having first rigged up to some convenient part a speed counter), open throttle fully, tighten down clamp y the screws (E) until engine is slowed to the required speed, namely, 1500 r. p. m. The number of ounds pull on arm (D) is now read off at (F).

Observe now the calculation. We first measure the distance from the central point of the flywheel to he point of the arm which rests on the scale. Assume this to be 3 ft., and the number of lbs. indicated n the scale to be 30, and we have all the necessary information.

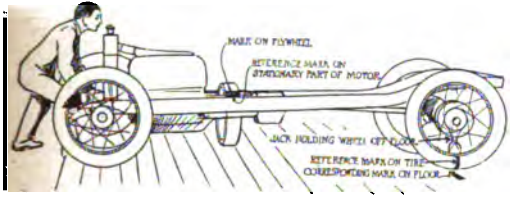
This arm is virtually the radius of an imaginary flywheel 6 ft. in diameter, which exerts at its rim— . e., at the point resting on the scale—a pull of 30 lbs.

Now a flywheel having a diameter of 6 ft. has, roughly, a circumference of 19 ft., and if its speed is o be 1500 r. p. m., we have here a rim speed of 28500 ft. per minute, exerting a pull of 30 lb., or, in ther words, 855000 ft. lbs. per minute. But, as we have seen, 33,000 ft. lbs. per minute is 1 h. p., thereore it requires but a simple division to find that the engine is developing nearly 26 h. p.

In actual practice, rather more elaboration is necessary to cope with secondary considerations. A uitable method of dealing with the friction on the flywheel, for instance, must be found. A proper lining for the braking clamp, so that the drag on the flywheel is constant, free from jerks, etc.

Relation of Speed of Engine to Road Wheels.

Fig. 5.—If you did not know the ratio between the speed of the engine and the speed of the car, there is a way of arriving at this ratio approximately. **Jack up both the rear wheels** as shown in fig. 5, and then after throwing the car into **low gear** crank the engine slowly by hand, counting the number of times the engine has to be completely turned over to one complete revolution of both rear wheels or two complete revolutions of one rear wheel. **First make a reference mark on the flywheel,** or take one of the timing marks as a reference, and after bringing this directly under the pointer, if there is one; or some other reference point on the flywheel housing, make a mark on the tire and another directly below this on the floor. **Now turn the engine slowly,** and when the rear wheel is again in line with its floor mark, count the number of times the flywheel has turned. If it has taken 20 revolutions of the engine, the ratio is 20 to 1, and so on. **Test intermediate and high gear** in the same manner. See page 22 for meaning of ratio and page 583; ratio of different cars.


MARK ON FLYWHEEL
REFERENCE MARK ON STATIONARY PART OF MOTOR
JACK HOLDING WHEEL OFF FLOOR
REFERENCE MARK ON TIRE
CORRESPONDING MARK ON FLOOR

How To Read a Taximeter.

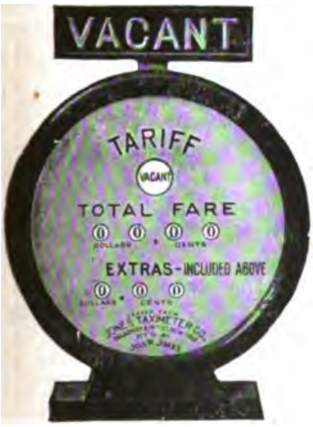


Fig. 1.

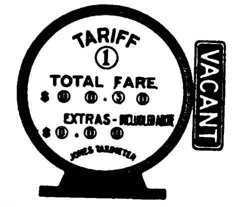


Fig. 2 — Taximeter starting with tariff sign showing one fare or passenger.

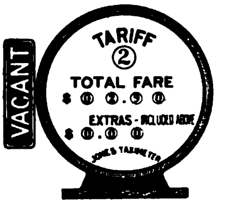


Fig. 3 — Taximeter with three or more persons.

A taximeter is used on taxicabs for the purpose of keeping tab on the distance traversed and cost per mile to a passenger.

When car is standing the meter is shown with the vacant sign standing upright and all dials at zero, per fig. 1.

When car starts on a trip with one or two persons, the "Vacant" sign is turned to the right, as shown in fig. 2. The tariff shows a figure 1, which means one fare to be charged. The total fare registers 30c which is the charge for the first one-half mile, and which is made when the vacant sign is first pulled to the right. After the first half-mile charge is recorded, the instrument automatically charges 10c for each additional quarter mile. In case a trunk is carried, the driver turns the knob on the reverse side of the instrument, which causes the trunk charge to be recorded, in the "extra" space, and also adds this amount of extra to the "total fare" already recorded. After the passenger leaves the taxicab and pays the fare, the vacant sign is returned to vertical position and figures again go to zero.

When three or more persons enter a taxicab, the "Vacant" sign is turned to the left as shown in fig. 3. The initial charge of 30c is the charge for the first one-third mile and additional 10c for each additional one-sixth mile (note difference of one fare and double fare charge).

When taxicab is kept waiting, there is a clock mechanism which, when the "Vacant" sign is down and the vehicle standing, a charge of 10c is registered for the first 6 minutes, and a similar charge for each additional 6 minutes of waiting. (Note this may vary in different localities.)

CHART NO. 225—The Prony Brake H. P. Test. Ratio of Speed of Engine to Road Wheels. How To Read a Taximeter.

*Piston Displacements of Four-Cylinder Engines in Cubic Inches.

$D^2 .7854\ SN = P.D$

PISTON DISPLACEMENTS Cubic Inches 4-CYL. ENGINES

Numbers at heads of columns are stroke lengths [Limit of Error=0.04 cu. in.]

Bore, Inches	3	3⅛	3¼	3⅜	3½	3⅝	3¾	3⅞	4	4⅛	4¼	4⅜	4½	4⅝	4¾	4⅞	5	5⅛	5¼	5⅜	5½
3	84.8	88.4	91.9	95.4	99.0	102.5	106.0	109.6	113.1	116.6	120.2	123.7	127.2	130.8	134.3	137.8	141.4	144.9	148.4	152.0	155.5
3 1/16	88.4	92.0	95.7	99.4	103.1	106.8	110.5	114.2	117.8	121.5	125.2	128.9	132.6	136.3	139.9	143.6	147.3	151.0	154.7	158.4	162.0
3⅛	92.0	95.9	99.7	103.5	107.4	111.2	115.0	118.9	122.7	126.5	130.4	134.2	138.1	141.9	145.7	149.6	153.4	157.2	161.1	164.9	168.7
3 3/16	95.8	99.7	103.7	107.7	111.7	115.7	119.7	123.7	127.7	131.6	135.6	139.6	143.6	147.6	151.6	155.6	159.6	163.5	167.5	171.5	175.5
3¼	99.5	103.7	107.8	112.0	116.1	120.3	124.4	128.5	132.7	136.8	141.0	145.1	149.3	153.4	157.6	161.7	165.9	170.0	174.2	178.2	182.5
3 5/16	103.4	107.7	112.0	116.3	120.6	125.0	129.3	133.6	137.9	142.2	146.5	150.8	155.1	159.4	163.7	168.0	172.4	176.7	181.0	185.3	189.6
3⅜	107.4	111.8	116.3	120.8	125.3	129.7	134.2	138.7	143.1	147.6	152.1	156.5	161.0	165.3	170.0	174.5	178.9	183.4	187.9	192.4	196.8
3 7/16	111.5	116.1	120.3	125.4	130.0	134.7	139.3	144.0	148.6	153.3	157.9	162.5	167.2	171.3	176.5	181.1	185.8	190.4	195.1	199.7	204.3
3½	115.4	120.3	125.1	129.9	134.7	139.5	144.3	149.1	153.9	158.7	163.5	168.4	173.2	178.0	182.8	187.6	192.4	197.2	202.0	206.8	211.6
3 9/16	119.6	124.6	129.6	134.5	139.5	144.5	149.5	154.5	159.5	164.4	169.4	174.4	179.4	184.4	189.4	194.3	199.3	204.3	209.3	214.3	219.3
3⅝	123.9	129.0	134.2	139.3	144.5	149.7	154.8	160.0	165.1	170.3	175.5	180.6	185.8	190.9	195.3	201.3	206.4	210.6	216.7	221.9	227.1
3 11/16	128.2	133.5	138.8	144.2	149.5	154.8	160.2	165.5	170.9	176.2	181.5	186.9	192.2	197.6	202.9	208.2	213.6	218.9	224.3	229.6	234.9
3¾	132.5	138.0	143.6	149.1	154.6	160.1	165.6	171.2	176.7	182.2	187.7	193.3	198.8	204.3	209.9	215.4	220.9	226.4	231.9	237.4	242.9
3 13/16	137.0	142.7	148.4	154.4	159.8	165.5	171.3	177.0	182.7	188.4	194.1	199.8	205.5	210.7	216.9	225.6	228.3	234.0	239.7	245.4	251.2
3⅞	141.5	147.4	153.3	159.2	165.1	171.0	176.9	182.8	188.7	194.6	200.4	206.4	212.3	218.2	224.0	229.9	235.8	241.7	247.6	252.5	259.4
3 15/16	146.1	152.2	158.3	164.4	170.5	176.3	182.6	186.7	194.8	200.9	207.0	213.1	219.2	225.3	231.3	237.4	243.5	249.6	255.7	261.8	267.9
4	150.8	157.1	163.4	169.7	175.9	182.2	188.5	194.8	201.1	207.4	213.6	219.9	226.2	232.5	238.8	245.0	251.3	257.6	263.9	270.2	276.5
4 1/16	155.5	162.0	168.5	175.0	181.5	188.0	194.4	200.9	207.4	213.9	220.3	226.8	233.3	239.8	246.3	252.8	259.2	265.7	272.2	278.7	285.2
4⅛	160.4	167.0	173.7	180.4	187.1	193.8	200.5	207.1	213.8	220.5	227.2	233.9	240.5	247.2	253.9	260.6	267.3	274.0	280.6	287.3	294.0
4 3/16	165.3	172.2	179.0	185.9	192.8	199.7	206.6	213.5	220.4	227.2	234.2	241.0	247.9	254.8	261.7	268.6	275.4	282.3	289.2	296.1	303.0
4¼	170.2	177.3	184.4	191.4	198.5	205.6	212.7	219.8	226.9	234.0	241.1	248.2	255.3	262.3	269.4	276.5	283.6	290.7	297.8	304.9	312.0
4 5/16	175.3	182.6	189.9	197.2	204.5	211.8	219.1	226.4	233.7	241.0	248.3	255.6	262.9	270.2	277.5	284.9	292.1	299.4	306.7	314.0	321.3
4⅜	180.4	187.9	195.4	202.9	210.5	218.0	225.5	233.0	240.5	248.0	255.5	263.1	270.6	278.1	285.6	293.1	300.7	308.2	315.7	323.2	330.7
4 7/16	185.6	193.3	201.1	208.8	216.5	224.3	232.0	239.7	247.5	255.2	262.9	270.7	278.4	286.1	293.8	301.6	309.8	317.1	324.8	332.5	340.2
4½	190.9	198.8	206.8	214.7	222.7	230.6	238.6	246.5	254.5	262.4	270.4	278.3	286.3	294.2	302.2	310.2	318.1	326.1	334.0	341.9	349.9
4 9/16	196.2	204.4	212.5	220.7	228.9	237.1	245.2	253.4	261.6	269.8	278.0	286.1	294.3	302.5	310.7	318.8	327.0	335.2	343.4	351.5	359.7
4⅝	201.6	210.0	218.4	226.8	235.2	243.6	252.0	260.4	268.8	277.2	285.6	294.0	302.4	310 8	319.2	327.6	336.0	344.4	352.8	361.2	369.6
4 11/16	207.1	215.7	224.3	233.0	241.6	250.2	258.9	267.5	276.1	284.7	293.4	302.0	310.6	319.2	327.9	336.5	345.1	353.8	362.4	371.0	379.6
4¾	212.7	221.5	230.4	239.2	248.1	257.0	265.8	274.7	283.5	292.4	301.2	310.1	319.0	327.8	336.7	345.6	354.4	363.3	372.1	381.0	389.9
4 13/16	218.3	227.4	236.5	245.6	245.7	263.8	272.9	281.9	291.1	300.1	309.2	318.3	327.4	336.5	345.6	354.7	363.8	372.9	382.0	391.1	400.2
4⅞	224.0	233.3	242.6	252.0	261.3	270.6	280.0	289.3	298.6	308.0	317.3	326.6	336.0	345.3	354.6	364.0	373.3	382.6	392.0	401.3	410.6
4 15/16	229.8	239.3	248.9	258.5	268.1	277.6	287.2	296.8	306.3	315.9	325.5	335.1	344.6	354.2	363.8	373.4	382.9	392.5	402.1	411.6	421.2
5	235.6	245.4	255.3	265.1	274.9	284.7	294.5	304.3	314.1	324.0	333.8	343.6	353.4	363.2	373.0	382.9	392.7	402.5	412.3	422.1	431.9
5 1/16	241.5	252.6	261.7	271.7	281.8	291.8	301.9	312.0	322.1	332.1	342.2	352.2	362.3	372.4	382.4	392.5	402.6	412.6	422.7	432.8	442.8
5⅛	247.6	257.9	268.2	278.5	288.8	299.1	309.4	319.8	330.1	340.4	350.7	361.0	371.3	381.6	392.0	402.3	412.6	422.9	433.2	443.5	453.8
5 3/16	253.6	264.2	274.7	285.3	295.9	306.5	317.0	327.6	338.1	348.7	359.3	369.8	380.4	391.0	401.5	412.1	422.7	433.2	443.8	454.4	465.0
5¼	259.8	270.6	281.4	292.2	303.0	313.9	324.7	335.5	346.3	257.2	368.0	378.8	389.6	400.4	411.3	422.1	432.9	443.7	454.6	465.4	476.2
5 5/16	266.	277.1	288.2	299.3	310.3	321.4	332.5	343.6	354.7	365.7	376.8	387.9	399.0	410.1	421.2	432.3	443.3	454.4	465.5	476.6	487.7
5⅜	272.3	283.7	295.	306.4	317.7	329.0	340.4	351.7	363.1	374.4	385.8	397.1	408.5	419.8	431.2	442.5	453.9	465.2	476.5	487.9	499.2
5 7/16	278.6	290.3	301.9	313.5	325.1	336.7	348.3	359.9	371.5	383.1	394.7	406.3	418.0	429.6	441.2	452.8	464.4	476.0	487.6	499.2	510.8
5½	285.1	297.0	308.8	320.7	332.6	344.5	356.4	368.2	380.1	392.9	403.8	415.7	427.6	439.5	451.4	463.3	475.2	487.0	498.9	510.8	522.7
5 9/16	291.6	303.7	315.9	328.0	340.2	352.3	364.5	376.6	388.8	400.9	413.1	425.2	437.4	449.5	461.7	473.8	486.0	498.1	510.3	522.4	534.6
5⅝	295.2	310.6	323.1	335.5	347.9	360.3	372.7	385.2	397.6	410.0	422.4	434.9	447.3	459.7	472.1	484.6	497.0	509.4	521.8	534.2	546.7
5 11/16	304.9	317.8	330.2	343.0	355.7	368.4	381.0	393.7	406.5	419.7	431.9	444.6	457.3	470.0	482.7	495.4	508.1	520.8	533.5	546.2	558.9
5¾	311.6	324.6	337.6	350.6	363.5	376.5	389.5	402.5	415.5	428.5	441.4	454.4	467.4	480.4	493.6	506.4	519.4	532.3	545.3	558.2	571.3
5 13/16	318.4	331.7	344.9	358.2	371.5	384.7	398.0	411.3	424.5	437.8	451.1	464.3	477.6	490.9	504.1	517.4	530.7	544.0	557.2	570.4	583.7
5⅞	325.3	338.8	352.4	366.0	379.5	393.1	406.6	670.1	433.9	447.8	460.8	474.4	487.9	501.5	515.0	528.6	540.2	555.7	569.2	582.8	596.3
5 15/16	332.2	346.0	359.9	373.7	387.6	401.4	415.3	429.1	442.9	456.8	470.6	484.5	498.3	512.2	526.0	539.8	553.7	567.6	581.4	595.2	609.0
6	339.3	354.4	367.6	381.7	395.8	410.0	424.1	438.2	452.4	466.5	480.6	494.8	508.9	523.0	537.2	551.3	565.5	579.6	593.7	607.8	622.0
6 1/16	346.4	360.8	375.2	389.7	404.1	418.5	433.0	417.4	461.8	476.3	490.7	505.1	519.6	534.0	548.4	562.9	577.3	591.7	606.2	620.6	635.0
6⅛	353.5	368.2	383.0	397.7	412.4	427.2	441.9	456.6	471.4	486.1	500.8	515.6	530.3	545.0	559.7	574.5	589.2	604.0	618.7	633.4	648.2
6 3/16	360.8	375.8	390.8	405.9	420.9	435.9	451.0	466.0	481.1	496.1	511.1	526.1	541.2	556.2	571.2	586.3	601.3	616.4	631.3	646.4	661.4
6¼	368.1	383.5	398.8	414.2	429.5	444.8	460.2	475.5	490.8	506.2	521.5	536.8	552.2	567.5	582.9	598.2	613.6	628.9	644.2	659.6	674.9
6 5/16	375.5	391.2	406.8	422.5	438.1	453.8	469.4	485.1	500.7	516.4	532.0	547.6	563.3	579.0	594.6	610.3	625.9	641.6	657.2	672.8	688.5
6⅜	383.0	398.0	414.9	430.9	446.8	462.8	478.8	494.7	510.7	526.6	542.6	558.5	574.5	590.4	606.4	622.4	638.4	654.3	670.2	686.2	702.1
6 7/16	390.6	406.8	423.1	439.4	455.7	471.9	488.2	504.4	520.7	537.0	553.3	569.5	585.8	602 1	618.4	634.6	650.9	667.2	683.5	699.7	716.0
6½	398.2	414.7	431.3	447.9	464.5	481.1	497.7	514.3	530.9	547.5	564.0	580.7	597.2	613.8	630.4	647.0	663.6	680.2	696.8	713.4	729.9
6 9/16	405.9	422.7	439.7	456.6	473.5	490.4	507.3	524.2	541.1	558.0	574.9	591.8	608.8	625.6	642.6	659.5	676.4	693.3	710.2	727.1	744.0
6⅝	413.6	430.8	448.1	465.3	482.5	499.8	517.0	534.2	551.5	568.7	585.9	603.2	620.4	637.6	654.9	672.1	689.3	706.6	723.8	741.0	758.3
6 11/16	421.5	439.1	456.7	474.2	491.8	509.3	526.9	544.5	562.0	579.6	597.1	614.7	632.3	649.8	667.4	685.0	702.5	720.1	737.6	755.2	772.8
6¾	429.4	447.3	465.2	483.1	501.0	518.9	536.8	554,6	572.6	590.4	608.3	626.2	644.1	662.0	679.9	697.8	715.7	733.6	751.5	769.4	787.3
6 13/16	437.5	455.7	473.9	492.1	510.4	528.6	546.8	565.0	583.2	601.5	619.7	637.9	656.2	674.4	692.6	710.8	729.0	747.3	765.5	783.8	802.0
6⅞	445.5	464.1	482.6	501.2	519.7	538.3	556.9	575.4	594.0	612.6	631.1	649.7	668.2	686.8	705.4	724.0	742.5	761.1	779.6	798.2	816.8
6 15/16	453.6	472.5	491.4	510.3	529.2	548.1	567.0	585.9	604.8	623.7	642.6	661.5	680.4	699.3	718.2	737.1	756.0	775.0	793.8	812.6	831.6

**Piston Displacement of Six-Cylinder Engines in Cubic Inches.

STROKE IN INCHES

Bore, Inches	4	4⅛	4¼	4⅜	4½	4⅝	4¾	4⅞	5	5⅛	5¼	5⅜	5½
2½....	117.8	121.5	125.2	128.9	132.5	136.2	139.9	143.6	147.2	150.9	154.6	158.3	162.0
2 9/16...	123.8	127.6	131.5	135.4	139.2	143.1	147.0	150.8	154.7	158.6	162.5	166.3	170.2
2⅝....	129.9	133.9	138.0	142.1	146.1	150.2	154.2	158.3	162.4	166.4	170.5	174.5	178.6
2 11/16...	136.1	140.4	144.7	148.9	153.2	157.4	161.7	165.9	170.2	174.4	178.7	182.9	178.2
2¾....	142.6	147.0	151.5	155.9	160.4	164.8	169.3	173.7	178.2	182.6	187.1	191.6	196.0
2 13/16...	149.1	153.8	158.4	163.1	167.7	172.4	177.0	181.7	186.4	191.0	195.7	200.4	205.0
2⅞....	155.8	160.7	165.5	170.4	175.3	180.1	185.0	189.9	194.8	199.6	204.5	209.4	214.2
2 15/16...	162.7	167.7	172.8	177.9	183.0	188.1	193.1	198.2	203.3	208.4	213.5	218.6	223.6
3.....	169.6	174.9	180.2	185.5	190.8	196.1	201.4	206.7	212.0	217.3	222.6	227.9	233.2
3 1/16...	176.8	182.3	187.8	193.4	198.9	204.4	209.9	215.4	221.0	226.5	232.0	237.5	243.1
3⅛....	184.1	189.8	195.6	201.3	207.1	212.8	218.6	224.4	230.1	235.9	241.6	247.4	253.1
3 3/16...	191.5	197.5	203.5	209.5	215.4	221.4	227.4	233.4	239.4	245.4	251.4	257.3	263.3
3¼....	199.1	205.3	211.5	217.8	224.0	230.2	236.4	242.6	248.9	255.1	261.3	267.5	273.7
3 5/16...	206.8	213.3	219.8	226.2	232.7	239.1	245.6	252.1	258.5	265.0	271.5	277.9	284.4
3⅜....	214.7	221.4	228.1	234.8	241.6	248.3	255.0	261.7	268.4	275.1	281.8	288.5	295.3
3 7/16...	222.7	229.7	236.7	243.6	250.6	257.5	264.5	271.5	278.4	285.4	292.3	299.3	306.3
3½....	230.9	238.1	245.3	252.6	259.8	267.0	274.2	281.4	288.6	295.9	303.1	310.3	317.5
3 9/16...	239.2	246.7	254.2	261.7	269.1	276.6	284.1	291.6	299.0	306.6	314.0	321.5	328.9
3⅝....	247.4	255.2	262.9	270.6	278.4	286.1	293.8	301.6	309.3	317.0	234.8	332.5	340.3
3 11/16...	256.3	264.3	272.3	280.3	288.4	296.4	304.4	312.4	320.4	328.4	336.4	344.4	352.4
3¾....	265.1	273.4	281.7	290.0	298.2	306.5	314.8	323.1	331.4	339.7	347.9	356.2	364.5
3 13/16...	274.0	282.5	291.1	299.7	308.2	316.8	325.4	333.9	342.5	351.0	359.6	368.2	376.7
3⅞....	283.0	291.8	300.7	309.5	318.4	327.2	336.1	345.0	353.8	362.6	371.4	380.3	389.1
3 15/16...	292.2	301.3	310.5	319.6	328.7	337.9	347.0	356.1	365.3	374.4	383.5	392.7	401.8
4.....	301.6	311.0	320.4	329.9	339.3	348.7	358.1	367.6	377.0	386.4	395.8	405.3	414.7
4 1/16...	311.1	320.8	330.5	340.3	350.0	359.8	369.4	379.1	388.9	398.6	408.3	418.0	427.8
4⅛....	320.7	330.8	340.8	350.8	360.8	370.9	380.9	390.9	400.9	410.9	421.0	431.0	441.0
4 3/16...	330.5	340.9	351.2	361.5	371.8	382.2	392.5	402.8	413.2	423.5	433.8	444.1	454.5
4¼....	340.5	351.1	361.8	372.4	383.0	393.7	404.3	415.0	425.6	436.2	446.9	457.5	468.2
4 5/16...	350.6	361.5	372.5	383.4	394.4	405.3	416.3	427.2	438.2	449.1	460.1	471.1	482.0
4⅜....	360.8	372.1	383.3	394.6	405.9	417.2	428.4	439.7	451.0	462.3	473.5	484.8	496.1
4 7/16...	371.2	382.8	394.4	406.0	417.6	429.2	440.8	452.4	464.0	475.6	487.2	498.8	510.4
4½....	381.7	393.6	405.6	417.5	429.4	441.3	453.3	465.2	477.1	489.1	501.0	512.9	524.8
4 9/16...	392.4	404.6	416.9	429.2	441.4	453.7	466.0	478.2	490.5	502.7	515.0	527.3	539.5
4⅝....	403.2	415.8	428.4	441.0	453.6	466.2	478.8	491.4	504.0	516.6	529.2	541.8	554.4
4 11/16...	414.2	427.1	440.1	453.0	466.0	478.9	491.8	504.8	517.7	530.7	543.6	556.6	569.5
4¾....	425.3	438.6	451.9	465.2	478.5	491.7	505.0	518.3	531.6	544.9	558.2	571.5	584.8
4 13/16...	436.6	450.2	463.8	477.5	491.1	504.8	518.4	532.1	545.7	559.3	573.0	586.6	600.3
4⅞....	448.0	462.0	476.0	490.0	504.0	518.0	532.0	546.0	560.0	574.0	588.0	602.0	616.0
4 15/16...	459.5	473.9	488.3	502.6	517.0	531.3	545.7	560.1	574.4	588.8	603.1	617.5	631.9
5.....	471.2	486.0	500.7	515.4	530.1	544.9	559.6	574.3	589.0	603.8	618.5	633.2	648.0
5 1/16...	483.1	498.2	513.3	528.4	543.5	558.6	573.7	588.8	603.9	619.0	634.1	649.2	664.3
5⅛....	495.1	510.6	526.0	541.5	557.0	572.5	587.9	603.4	618.9	634.3	649.8	665.3	680.8
5 3/16...	507.2	523.1	538.9	554.8	570.6	586.5	602.4	618.2	634.1	649.9	665.8	681.6	697.5
5¼....	519.5	535.8	552.0	568.3	584.5	600.7	617.0	633.2	649.4	665.7	681.9	698.1	714.4
5 5/16...	532.0	548.6	565.2	581.9	598.5	615.1	631.7	648.4	665.0	681.6	698.2	714.9	731.5
5⅜....	544.6	561.6	578.6	595.6	612.7	629.7	646.7	663.7	680.7	697.7	714.8	731.8	748.8
5 7/16...	557.3	574.7	592.1	609.6	627.0	644.4	661.8	679.2	696.6	714.1	731.5	748.9	766.3
5½....	570.2	588.0	605.8	623.7	641.5	659.3	677.1	694.9	712.8	730.6	748.4	706.2	784.0

Piston Displacement.

Piston displacement means the actual number of cubic inches displaced by the movement of all the pistons from one end of the stroke to the other. Considering just one piston it equals cross sectional area of cylinder in square inches multiplied by the length of the stroke in inches, and in a four-cylinder engine, for instance, the total displacement would be four times this amount.

How to find piston displacement—the formula would be designated thus: D^2 x .7854 x S x N = piston displacement. D^2 means diameter or bore squared or multiplied by itself as 5 x 5. This result is then multiplied by the **constant** .7854 (the area of a cylinder 1 inch in diameter), this result by (S) the stroke in inches and this result by (N) the number of cylinders.

Example: What is the piston displacement of four cylinders, four inch bore and 5½ inch stroke? Procedure—4 x 4 = 16 x .7854 = 12.566 x 5½ (or 5.5) = 69.115 x 4 = 276.5 cubic inches.

Example: What is the piston displacement of four cylinders, 3⅛ inch bore and 4⅝ inch stroke? Procedure—3⅛ x 3⅛ x .7854 x 4⅝ x 4 = 141.9 cubic inch piston displacement.

For larger stroke and bore than given in table take the dimensions from the table that would be one half of what you want and double it.

McCullough Formula for Finding the Speed of a Car.

Engine speed per minute x diameter in inches of rear wheel x .002975 ÷ ratio.

Ratio of drive, for example is 4 to 1, means engine crank shaft turns four times to one of rear axle. Therefore the figure to be used to divide by, would be four. The same holds good in all speeds no matter if in first, second, third or fourth speed.

Example; 1000 (rev. of engine) x 30 (di. in in. of wheel) x .002975 divided by 4 (4 to 1 ratio) equals 22.31 plus, miles per hour.

CHART NO. 226—Piston Displacements (from Automobile Trade Journal). **How to Find Speed of a Car.** *For 8 cyl. engines multiply given displacement by 2. **For 12 cyl. engines multiply by 2.

Grades.

he general assumption is that a grade of 100 per t. would be vertical or 90 degree angle as per e D, which is incorrect.

A grade is expressed in terms of percentage and ans so many feet rise or fall in a given distance asured in a horizontal direction. This given dis- ice may, for convenience, be 100, 500, 1000 t, etc.

A rise of 100 feet in the same distance meas- ed horizontally is a 100 per cent. grade; how- er, the included angle is 45 degrees and not 90°. g. 8 shows the grade percentage, which is based a horizontal distance (line B) of 100 feet.

Assume that line B is a straight line 100 feet ng and perfectly level, therefore from A to B ere would be no grade. If from A to B there is a rise of 1 foot in every 20 feet, when we ached line B, we would be 5 feet higher than at A, therefore this would be a 5 per cent. grade. It is not necessary however to travel the full distance, just so long as there is a rise of 1 foot to every 20 feet, it is a 5 per cent. grade at any point.

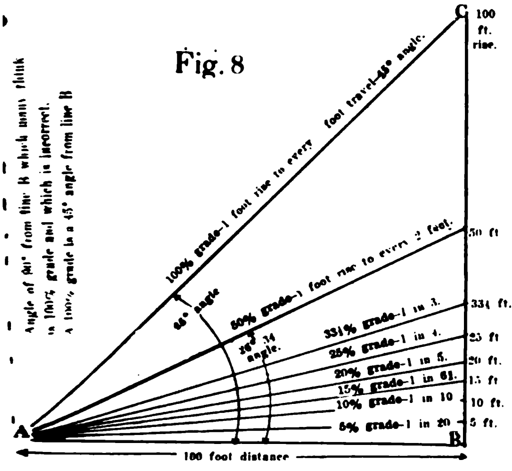

Angle of 90° from line B which many think is 100% grade and which is incorrect.
A 100% grade is a 45° angle from line B
C
100 ft. rise.
100% grade-1 foot rise to every foot travel-45° angle.
45° angle
50% grade-1 foot rise to every 2 feet.
26° 34 angle.
33⅓% grade-1 in 3.
25% grade-1 in 4.
20% grade-1 in 5.
15% grade-1 in 6⅔.
10% grade-1 in 10
5% grade-1 in 20
50 ft
33⅓ ft.
25 ft
20 ft.
15 ft
10 ft.
5 ft.
A
B
100 foot distance

Fig. 8

If the grade or steepness increased to 1 foot rise in 10 feet, then it would be a 10 per cent grade and we would be 10 feet higher at line B than at A; 1 in 6⅔ is a 1 foot rise in 6⅔ feet, and a 15 per cent grade, and so on up to 100 per cent grade, which would be a rise of 1 foot in 1 foot, as from A to C would represent the distance from A to B, or 100 feet, but in reality it is a greater distance, as we would not only travel the distance from A to B but we must also travel included angle of 45 degrees.

To ascertain the percentage of a grade without the use of any special instruments: secure a spirit level and a ten-foot stick. Rest one end of stick on the road surface and find its level position with spirit level, by placing this on the stick and raising or lowering the stick until bubble is in center.

Then measure the perpendicular distance between end of stick and road surface and multiply by 10, which will give the rise in feet in proportion to one hundred feet.

For example, the perpendicular distance measured 18 inches; this multiplied by 10 gives 180 inches, and reduced to feet gives 15 feet as the rise in one hundred feet or 15 per cent grade.

The average of such measurements taken on grades will give fairly accurate results.

Per Cent		Angle
100	1′ in 1′	45°
50	1′ in 2′	26° 34′
25	1′ in 4′	14° 2′
20	1′ in 5′	11° 19′
15	1′ in 6⅔′	8° 37′
10	1′ in 10′	5° 43′
5	1′ in 20′	2° 52′

The affix to figures in center column, as 1′, means 1 foot; whereas in right hand column, as 34′, it means 34 minutes—see pages 93 and 541 for meaning of degrees and minutes.

A 66⅔ per cent grade is as steep as a car could possibly climb, as gravity overcomes traction at this angle.

MELTING POINTS

	Fahrenheit Degrees	Centigrade Degrees		Fahrenheit Degrees	Centigrade Degrees
ALUMINUM	1216	658	NICKEL	2642	1450
ANTIMONY	1166	630	PALLADIUM	2822	1550
Arsenic	1472	800	Phosphorus	111	44
Bismuth	518	270	PLATINUM	3191	1755
CADMIUM	610	321	POTASSIUM	144	62
Calcium	1481	805	Rhodium (?)	3452	1900
Chromium	2741	1505	Silicon	2588	1420
COBALT	2714	1490	SILVER	1762	961
COPPER	1981	1083	SODIUM	207	97
GOLD	1945	1063	Tantalum (?)	5252	2900
Iridium (?)	4172	2300	TIN	450	232
IRON	2768	1520	Titanium (?)	3362	1850
LEAD	621	327	TUNGSTEN	5432	3000
Magnesium	1204	651	Uranium	4352	2400
Manganese	2237	1225	Vanadium (?)	3182	1750
MERCURY	—38	—39	ZINC	786	419
Molybdenum (?)	4532	2500			
GLASS	1832	1000	Sulphur	237 248	114 120
GLASS, LEAD FREE	2192	1200	Fusible Metals:		
DELTA METAL	1742	950	1 Tin, 2 Lead	361	183
BARIUM CHLORIDE	1635	891	1 Tin, 1 Lead	304	151
POTASSIUM FERRO-CYANIDE	1145	618	3 Tin, 2 Lead	275	135
POTASSIUM CHLORIDE	1325	718	4 Tin, 4 Lead, 1 Bismuth	263	128
SODIUM CHLORIDE	1472	800	3 Tin, 5 Lead, 8 Bismuth	212	100

See chart 227 for Centigrade to Fahrenheit.

TABLE OF CYLINDER BORES AND STROKES IN MILLIMETRES AND INCHES.

The following figures are approximate, and intended only as a rough guide for comparison. For accurate measurements a sliding calliper with inches and metric scales should be used:

A Cylinder	Equals in Inches	A Cylinder	Equals in Inches
66 by 70 millimetres ...	2 9/16 by 2¾	84 by 90 millimetres ...	3 5/16 by 3 9/16
67 „ 70 „ ...	2⅝ „ 2¾	90 „ 90 „ ...	3 9/16 „ 3 9/16
67 „ 73 „ ...	2⅝ „ 2⅞	90 „ 110 „ ...	3 9/16 „ 4 5/16
67 „ 77 „ ...	2⅝ „ 3	96 „ 115 „ ...	3¾ „ 4 9/16
70 „ 70 „ ...	2¾ „ 2¾	100 „ 115 „ ...	3 15/16 „ 4 9/16
70 „ 73 „ ...	2¾ „ 2⅞	105 „ 118 „ ...	4⅛ „ 4⅝
70 „ 77 „ ...	2¾ „ 3	108 „ 120 „ ...	4¼ „ 4¾
72 „ 77 „ ...	2 13/16 „ 3	110 „ 125 „ ...	4 5/16 „ 4 15/16
73 „ 73 „ ...	2⅞ „ 2⅞	112 „ 128 „ ...	4 7/16 „ 5 1/16
73 „ 80 „ ...	2⅞ „ 3⅛	114 „ 130 „ ...	4½ „ 5⅛
77 „ 77 „ ...	3 „ 3	116 „ 134 „ ...	4 9/16 „ 5 5/16
77 „ 80 „ ...	3 „ 3⅛	118 „ 138 „ ...	4⅝ „ 5 7/16
77 „ 83 „ ...	3 „ 3¼	120 „ 140 „ ...	4¾ „ 5½
78 „ 78 „ ...	3 1/16 „ 3 1/16	122 „ 143 „ ...	4 13/16 „ 5⅝
80 „ 80 „ ...	3⅛ „ 3⅛	124 „ 146 „ ...	4⅞ „ 5¾
80 „ 86 „ ...	3⅛ „ 3⅜	126 „ 148 „ ...	4 15/16 „ 5 13/16
83 „ 83 „ ...	3¼ „ 3¼	128 „ 150 „ ...	5 1/16 „ 5 15/16
83 „ 86 „ ...	3¼ „ 3⅜	130 „ 152 „ ...	5⅛ „ 6
86 „ 86 „ ...	3⅜ „ 3⅜	140 „ 160 „ ...	5½ „ 6¼

Miscellaneous Tables.

To convert metres to yards, multiply by 70 and divide by 64.

To convert kilometres to miles, multiply by 5 and divide by 8 (approx.)

To convert litres to pints, multiply by 88 and divide by 50.

To convert grams to ounces, multiply by 567 and divide by 20.

To convert inches to centimetres, multiply by 2.54.

To convert cubic inches to cubic centimetres, multiply by 6.39.

To convert cubic metres to cubic feet, multiply by 35.32.

To convert gallons of water to lbs., multiply by 10.

To find the cubical contents of an engine cylinder, square the diameter (or bore) multiply by .7854 and multiply the result by the stroke.

Atmospheric pressure equals 14.7 lbs. per square inch at sea level.

To find circumference of a circle multiply diameter by 3.1416.

To find diameter of a circle multiply circumference by .31831.

To find area of a circle multiply square of diameter by .7854.

To find area of a triangle multiply base by ½ perpendicular height.

To find surface of a ball multiply square of diameter by 3.1416.

To find solidity of a sphere, multiply cube of diameter by .5236.

To find cubic inches in a ball multiply cube of diameter by .5236.

Doubling the diameter of a pipe increases its capacity four times.

A cubic foot of water contains 7½ gallons, 1.728 cubic ins., and weighs 62½ pounds.

HART NO. 226-A—How to Find Grade. Miscellaneous Tables. Melting Point of Metals. (See hart 236-A for Metric size Tires into inches.)

ee page 585 and index for freezing point, boiling point and specific gravity of water, alcohol, gasoline and kero- ene, also freezing and boiling point of mercury.

*Time per Mile Expressed in Miles per Hour

Time for one mile Min.	Sec.	Miles Per hour	Time for one mile Min.	Sec.	Miles Per hour	Time for one mile Min.	Sec.	Miles Per hour
0	36	100.00	1	12	50.00	1	47	33.64
0	37	97.30	1	13	49.31	1	48	33.33
0	38	94.74	1	14	48.65	1	49	33.03
0	39	92.31	1	15	48.00	1	50	32.72
0	40	90.00	1	16	47.37	1	51	32.42
0	41	87.80	1	17	46.75	1	52	32.14
0	42	85.71	1	18	46.15	1	53	31.86
0	43	83.72	1	19	45.57	1	54	31.58
0	44	81.82	1	20	45.00	1	55	31.30
0	45	80.00	1	21	44.44	1	56	31.03
0	46	78.26	1	22	43.90	1	57	30.77
0	47	76.60	1	23	43.37	1	58	30.50
0	48	75.00	1	24	42.86	1	59	30.25
0	49	73.47	1	25	42.35	2	0	30.00
0	50	72.00	1	26	41.86	2	3	29.26
0	51	70.59	1	27	41.38	2	6	28.57
0	52	69.23	1	28	40.91	2	9	27.90
0	53	67.92	1	29	40.45	2	12	27.27
0	54	66.67	1	30	40.00	2	15	26.66
0	55	65.45	1	31	39.56	2	18	26.08
0	56	64.29	1	32	39.13	2	21	25.53
0	57	63.16	1	33	38.71	2	24	25.00
0	58	62.07	1	34	38.30	2	27	24.49
0	59	61.02	1	35	37.89	2	30	24.00
1	0	60.00	1	36	37.50	2	33	23.53
1	1	59.02	1	37	37.11	2	36	23.07
1	2	58.06	1	38	36.73	2	39	22.64
1	3	57.14	1	39	36.36	2	42	22.22
1	4	56.25	1	40	36.00	2	45	21.81
1	5	55.38	1	41	35.64	2	48	21.42
1	6	54.55	1	42	35.29	2	51	21.05
1	7	53.73	1	43	34.95	2	54	20.69
1	8	52.94	1	44	34.61	3	0	20.00
1	9	52.17	1	45	34.28	..	..	....
1	10	51.43	1	46	33.96			
1	11	50.70						

*There are 3600 seconds in an hour and to find the speed in miles per hour—divide 3600 by the time in seconds it takes to make 1 mile.

Miles and Kilometres

Kilo.	Miles.	Kilo.	Miles.	Kilo.	Miles.	Kilo.	Miles.
1	⅝	20	12⅜	38	23⅝	56	34¾
2	1¼	21	13	39	24¼	57	35⅜
3	1⅞	22	13⅝	40	24⅞	58	36
4	2½	23	14¼	41	25½	59	36⅝
5	3⅛	24	14⅞	42	26⅛	60	37¼
6	3¾	25	15½	43	26¾	70	43½
7	4⅜	26	16⅛	44	27⅜	80	49¾
8	5	27	16¾	45	28	90	55⅞
9	5⅝	28	17⅜	46	28⅝	100	62⅛
10	6¼	29	18	47	29¼	200	124¼
11	6⅞	30	18⅝	48	29⅞	300	186⅜
12	7½	31	19¼	49	30½	400	248½
13	8⅛	32	19⅞	50	31⅛	500	310⅝
14	8¾	33	20½	51	31¾	600	372¾
15	9⅜	34	21⅛	52	32⅜	700	435
16	10	35	21¾	53	32⅞	800	497⅛
17	10⅝	36	22⅜	54	33½	900	559¼
18	11¼	37	23	55	34⅛	1000	621⅜
19	11⅞						

American Dirt Track Records 1 & 5 Miles.

1 m.	45 sec.	Oldfield, Miller, St. Louis,	Aug. 11, '17
5 m.	3:53.6	Oldfield, Miller, St. Louis,	Aug. 11, '17

Highest Speed Ever Traveled.

De Palma, Packard, averaged 150 m. p. h.

Millimeters to Inches (decimal).

Mm.	Inches	Mm.	Inches
		14 =	.55118
2 =	.07874	15 =	.59055
3 =	.11811	16 =	.62992
4 =	.15748	17 =	.66929
5 =	.19685	18 =	.70866
6 =	.23622	19 =	.74803
7 =	.27559	20 =	.78740
8 =	.31496	21 =	.82677
9 =	.35433	22 =	.86614
10 =	.39370	23 =	.90551
11 =	.43307	24 =	.94488
12 =	.47244	25 =	.98425
13 =	.51181	26 =	1.02362

Kilometers and Miles per Hour.

A Kilometre in Min.	Sec.	Miles per Hour	A Kilometre in Min.	Sec.	Miles per Hour
0	55	40.65	1	13	30.63
0	56	39.93	1	14	30.22
0	57	39.23	1	15	29.81
0	58	38.55	1	16	29.42
0	59	37.89	1	17	29.04
1	0	37.26	1	18	28.67
1	1	36.65	1	19	28.30
1	2	36.06	1	20	27.95
1	3	35.49	1	21	27.60
1	4	34.93	1	22	27.27
1	5	34.40	1	23	26.94
1	6	33.88	1	24	26.62
1	7	33.37	1	25	26.31
1	8	32.88	1	26	26.00
1	9	32.41	1	27	25.70
1	10	31.94	1	28	25.41
1	11	31.49	1	29	25.12
1	12	31.05	1	30	24.84

A Kilometre in Sec.	Miles per Hour.	A Kilometre in Sec.	Miles per Hour
16	139.79	37	60.43
18	124.26	38	58.84
20	111.83	39	57.33
21	106.50	40	55.90
22	101.66	41	54.53
23	97.24	42	53.24
24	93.19	43	52.00
25	89.54	44	50.82
26	86.02	45	49.69
27	82.83	46	48.61
28	78.88	47	47.57
30	74.53	48	46.58
31	72.13	49	45.63
32	69.87	30	44.72
33	67.76	51	43.84
34	65.76	52	43.00
35	63.88	53	42.19
36	62.11	54	41.40

Centigrade to Fahrenheit

Deg. Cent.	Deg. Fahr.	Deg. Cent.	Deg. Fahr.	Deg. Cent.	Deg. Fahr.	Deg. Cent.	Deg. Fahr.	Deg. Cent.	Deg. Fahr.	Deg. Cent.	Deg. Fahr.
—10	14	22	71.6	53	127.4	84	183.2	175	347	[illegible]	[illegible]
— 9	15.8	23	73.4	54	129.2	85	185	180	356	[illegible]	[illegible]
— 8	17.6	24	75.2	55	131	86	186.8	185	365	[illegible]	[illegible]
— 7	19.4	25	77	56	132.8	87	188.6	190	374	[illegible]	[illegible]
— 6	21.2	26	78.8	57	134.6	88	190.4	195	383	[illegible]	[illegible]
— 5	23	27	80.6	58	136.4	89	192.2	200	392	[illegible]	[illegible]
— 4	24.8	28	82.4	59	138.2	90	194	210	410	[illegible]	[illegible]
— 3	26.6	29	84.2	60	140	91	195.8	220	428	[illegible]	[illegible]
— 2	28.4	30	86	61	141.8	92	197.6	230	446	[illegible]	[illegible]
— 1	30.2	31	87.8	62	143.6	93	199.4	240	464	[illegible]	[illegible]
0	32	32	89.6	63	145.4	94	201.2	250	482	[illegible]	[illegible]
1	33.8	33	91.4	64	147.2	95	203	260	500	[illegible]	[illegible]
2	35.6	34	93.2	65	149	96	204.8	270	518	[illegible]	[illegible]
3	37.4	35	95	66	150.8	97	206.6	280	536	725	[illegible]
4	39.2	36	96.8	67	152.6	98	208.4	290	554	750	[illegible]
5	41	37	98.6	68	154.4	99	210.2	300	572	775	[illegible]
6	42.8	38	100.4	69	156.2	100	212	310	590	[illegible]	[illegible]
7	44.6	39	102.2	70	158	105	221	320	608	[illegible]	[illegible]
8	46.4	40	104	71	159.8	110	230	330	626	[illegible]	[illegible]
9	48.2	41	105.8	72	161.6	115	239	340	644	[illegible]	[illegible]
10	50	42	107.6	73	163.4	120	248	350	662	[illegible]	[illegible]
11	51.8	43	109.4	74	165.2	125	257	360	680	[illegible]	[illegible]
12	53.6	44	111.2	75	167	130	266	370	698	[illegible]	[illegible]
13	55.4	45	113	76	168.8	135	275	380	716	975	[illegible]
14	57.2	46	114.8	77	170.6	140	284	390	734	[illegible]	[illegible]
15	59	47	116.6	78	172.4	145	293	400	752	[illegible]	[illegible]
16	60.8	48	118.4	79	174.2	150	302	410	770	[illegible]	[illegible]
17	62.6	49	120.2	80	176	155	311	420	788	[illegible]	[illegible]
18	64.4	50	122	81	177.8	160	320	430	806	1100	[illegible]
19	66.2	51	123.8	82	179.6	165	329	440	824	1125	[illegible]
20	68	52	125.6	83	181.4	170	338	450	842	1150	[illegible]
21	69.8										

Wheel and engine speeds: This table gives the number of revolutions a tire of given size, makes in going a mile.

TIRE SIZE	WHEEL R.P.M.	ENGINE REVOLUTIONS PER MILE 3 to 1	3½ to 1	4 to 1	4½ to 1	5 to 1
30	672.2	1916.6	2242.7	2688.8	3024.9	3361.0
32	631.7	1895.1	2210.9	2526.8	2842.6	3158.5
33	611.1	1833.3	2138.8	2444.4	2749.9	3055.5
34	593.2	1779.6	2075.2	2372.8	2669.4	2966.0
35	576.2	1728.6	2016.7	2304.8	2592.9	2881.0
36	560.2	1680.6	1960.7	2240.8	2520.9	2801.0
40	504.2	1512.6	1764.6	2016.8	2268.8	2520.0

RPM	Stroke in Inches 3	3¼	3½	3¾	4	4¼	4½	4¾	5	5¼	5½	5¾
200	100	108	116	125	133	141	150	158	166	175	183	191
400	200	217	233	250	267	283	300	317	333	350	367	383
600	300	325	350	375	400	425	450	475	500	525	550	575
800	400	434	466	500	534	566	600	634	666	700	734	766
1000	500	542	584	625	676	708	750	792	834	875	917	958
1200	600	650	700	750	800	850	900	950	1000	1050	1100	1150
1400	700	766	816	875	934	992	1100	1108	1165	1225	1282	1342
1600	800	868	932	1000	1068	1132	1200	1268	1332	1400	1468	1532
1800	900	975	1050	1125	1200	1275	1350	1425	1500	1575	1650	1725
2000	1000	1084	1168	1250	1352	1416	1500	1584	1668	1750	1832	1916

Fig. 9. Table: gives the piston travel in feet per minute of engines with different strokes with various crank-shaft speeds. Example: How many feet would a piston travel in an engine with a 3 inch stroke when crank-shaft was turning 200 rev. per min. (r.p.m.)? Ans.: The piston goes down 3 inches and up 3 inches to one rev. of crank-shaft, therefore 3 inches down and 3 inches up would be 6 inches of travel of piston to one rev. of crank-shaft. To 200 rev. of crank-shaft, piston would travel 200×6=1200 inches. If there are 12 inches to a foot, then we would have 1200÷12=100 feet of piston travel per min. to 200 rev. of crank-shaft.

This formula would be: $P = \frac{S \times 2 \times R}{12}$. P, is piston travel per min. which equ the stroke S, x2, xR (the rev. per min. crank-shaft) divided by 12.

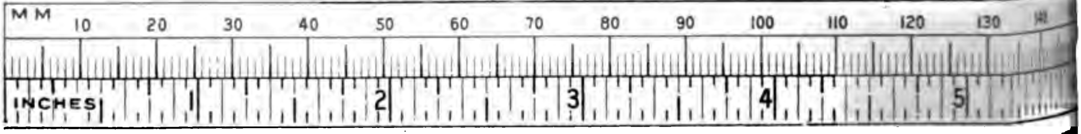


CHART NO. 227—Miscellaneous Tables. The scale rule at bottom of this page is exact size and show parative difference between millimeters and inches.

Degrees, Thousandths of an Inch, Millimeters, Etc.

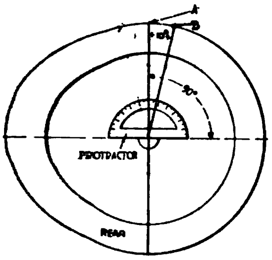
Degrees.

A degree is a unit employed in measuring **gles and** is the ninetieth part of a right angle or **e three**-hundred and sixtieth part of a circle.

The degree explanation is given on page 98. **e also pages** 115 and 314, "converting degrees **to inches.**

The thousandth part of an inch is referred to **uite often** in this book, therefore a simple method **f finding** the measurement is given below. Also **e foot** note.

Hundredths of an inch to sixty-fourths of an **nch is given** on page 115.



The metric system—called the French standard, is used quite extensively abroad and is also referred to quite often in this book. Therefore a conversion of those figures most generally used is given, see charts 226A, 227, 236A.

††A protractor is used for dividing circles into **any number** of equal parts or degrees and determining angles.

For instance, to find the number of degrees in a circle with a protractor; say a fly wheel of an **engine.** Place protractor as shown. From the **center** line (A) to (B) is 10°; from (A) to the **extreme** right, lower part of protractor—if a line **was drawn**—you would have a right angle or 90°. **The** number of degrees from extreme left to extreme right of protractor would be 180°, or half **a circle.** The entire circle would be 360°. In **other** words the circle is divided into 360 equal **parts** called degrees and designated with a **small** "o."

We can divide each degree into 60 parts called "**minutes,**" and each minute can be divided into 60 parts called "seconds." One minute would be designated thus (1′) and one second thus (1″).

Signs or Symbols of Inches, Feet, Minutes and Seconds.

The sign for inches or seconds is (″) as 6″.

The sign for feet or minutes is (′) as 6′.

*Thousandths Part of an Inch.

.001 (one thousandth) = 1/3 thickness of this sheet of paper or about the thickness of fine tissue paper.

.003 (three thousandths) = thickness of this page you are reading.†

.006 (six thousandths) = thickness of two sheets of this paper.

.015 (fifteen thousandths) = thickness of five sheets of this paper.

.020 (twenty thousandths) = thickness of seven sheets of this paper.

.025 (twenty-five thousandths) = thickness of eight and one-third sheets.

.030 (thirty thousandths) = thickness of ten sheets.

Decimal Equivalent of Fractional Parts of an Inch.

In using this table it is not necessary to carry out all of the fraction. As a rule, three figures to right of decimal point is close enough for all practical purposes—which would be, of course, read in thousandths, as .015 (fifteen thousandths).

8ths

1/8 = .125
1/4 = .250
3/8 = .375
1/2 = .500
5/8 = .625
3/4 = .750
7/8 = .875

16ths

1/16 = .0625
3/16 = .1875
5/16 = .3125
7/16 = .4375
9/16 = .5625
11/16 = .6875
13/16 = .8125
15/16 = .9375

32ds

1/32 = .03125
3/32 = .09375
5/32 = .15625
7/32 = .21875
9/32 = .28125
11/32 = .34375
13/32 = .40625
15/32 = .46875
17/32 = .53125
19/32 = .59375
21/32 = .65625
23/32 = .71875
25/32 = .78125
27/32 = .84375
29/32 = .90625
31/32 = .96875

64ths

1/64 = .015625
3/64 = .046875
5/64 = .078125
7/64 = .109375
9/64 = .140625
11/64 = .171875
13/64 = .203125
15/64 = .234375
17/64 = .265625
19/64 = .296875
21/64 = .328125
23/64 = .359375
25/64 = .390625
27/64 = .421875
29/64 = .453125
31/64 = .484375
33/64 = .515625
35/64 = .546875
37/64 = .578125
39/64 = .609375
41/64 = .640625
43/64 = .671875
45/64 = .703125
47/64 = .734375
49/64 = .765625
51/64 = .796875
53/64 = .828125
55/64 = .859375
57/64 = .890625
59/64 = .921875
61/64 = .953125
63/64 = .984375

.015 is 1/64″; .025 is approximately 1/40″.

Millimeters to Inches.

m—is the designation of meter; cm—centimeter; m m or m/m—milli-meter.

1 millimetre is approximately 1/25 inch and is exactly .03937 inch.

1 centimetre is approximately 13/32 inch and is exactly .3937 inch.

1 metre is approximately 39¼ inches and is exactly 39.37 inches, or 1.0936 yards.

1 kilometre is approximately 5/8 mile and is exactly .6218 mile.

1 kilogramme is approximately 2¼ lbs. and is exactly 2.21 lbs.

1 litre is approximately 1¾ pints and is exactly 1.76 pints.

10 mm. = 1 Centimeter = 0.3937 inches.
10 cm. = 1 Decimeter = 3.937 inches.
10 dm. = 1 Meter = 39.37 inches.
25.4 mm. = 1 English inch.

**Millimeters to Fractions of an Inch.

1 mm. is approx. .... 3/64 inch
2 mm. is approx. .... 5/64 inch
3 mm. is approx. .... 7/64 inch
4 mm. is approx. .... 5/32 inch
5 mm. is approx. .... 13/64 inch
6 mm. is approx. .... 15/64 or 1/4 inch
7 mm. is approx. .... 17/64 inch
8 mm. is approx....... 20/64 or 10/32 or 5/16 inch
9 mm. is approx. .... 22/64 inch
10 mm. is approx. .... 25/64 inch
12 mm. is approx. .... 15/32 inch
15 mm. is approx. .... 19/32 inch
16 mm. is approx. .... 5/8 inch
18 mm. is approx. .... 23/32 inch
20 mm. is approx. .... 25/32 inch
22 mm. is approx. .... 55/64 inch
24 mm. is approx. .... 15/16 inch
25 mm. is approx. .... 63/64 inch

Tenths of Millimeters.

.2 (2/10ths) of a mm. is approx. .008 inch
.3 (3/10ths) of a mm. is approx. .012 inch
.4 (4/10ths) of a mm. is approx. .016 inch
.5 (5/10ths) of a mm. is approx. .019 inch

---

*See page 698 for micrometers and page 699 for thickness gauge for measuring thousandths of an inch. †The exact thickness of this page is .0028 (twenty-eight ten thousandths of an inch).

**See page 539 (cylinders) and 540 (miles) and 554 (tires) for metric conversions.

††By referring to page 707, measurement of angle of a drill is shown.

Note: Frequent reference to the index, for Valve Timing, Ignition Timing, etc., of different cars is Also see "Specifications of Leading Cars"—charts 229 to 232. This chart was prepared in 1916, and has been revised.

MAKE OF CAR	MODEL	NO OF CYLS	Bore and Stroke	Make of Engine	GEAR SHIFT MOVEMENTS				IGNITION TIMING				VALVE TIMING				VALVE CLEARANCE engine cold	DISTANCE TO SET SPARK PLUG GAP	DIST TO SET BREAKER POINTS
					1ST SPEED	2ND SPEED	3RD SPEED	REV.	INCHES OR DEG	INCHES OR DEG.	Retarded	Advanced	EC	IO.	EO.	IC.			
									After top	Before top									
ALLEN	37	4	3¾x5	OWN	LR	RF	RR	LF					10°	15°	45°	40°	.003	.025	.020
BRISCOE	24	4	3 7/16x5⅛	OWN	LR	RF	RR	LF			TR		10°	5°	47°	37°	.003	.031	.020
BRISCOE	38	8	3x3½	FERRO	LR	RF	RR	LF		30°			12°	14°	47°	47°	.003	.031	.020
* BUICK	D35	4	3⅜x4¾	OWN	LR	LF	RR	RF									.005	.025	.020
* BUICK	D44-45	6	3¾x4½	"	"	"	"	"	SEE INDEX		R						.005	.025	.020
CADILLAC	55	8	3⅛x5⅛	"	"	RF	RR	LF	"	"							.003	.028	.020
CHALMERS	35AB	6	3¼x4½	"	"	"	"	"			TR		10°	TC	50°	50°	.003	.025	.020
CHANDLER	17	6	3⅜x5	"	"	"	"	"			TR		10°	15°	50°	40°	.003	.025	.020
CHEVROLET	490	4	3 11/16x4	MASON	"	"	"	"			TR		16°	16°	40°	52°	.005	.020	.025
COLE	850	8	3½x4½	NORTHWAY	LR	RF	RR	LF									.004	.031	.025
DODGE		4	3⅞x4½	OWN	LF	RR	RF	LR			TR						.004	.031	.025
DORT	9	4	3¼x5	"	LR	RF	RR	LF	1½"		1½"RET		10°	5°	47°	37°	.002	.025	.025
ENGER	TWIN SIX	12	2 11/16x3½	"	"	"	"	"			TR			16°			.004	.025	.025
FORD	T	4	3¾x4	"	SEE FORD SUPLEMENT													.031	
FRANKLIN	9	6	3¼x4	"	RR	LF	LR	RF	2IN BEFORE CENTER AS MARKED ON FLY WHEEL		RET'D		AS PER MARKS ON FLY WHEEL				.010	.031	.010
HAYNES	36	6	3½x5	"	LR	RF	RR	LF	1/16				2°	5°	47°	35°	.003	.020	.018
HAYNES	40	12	2¾x5	"	"	"	"	"					2°	5°	47°	34½°			
HUDSON	SUPER	6	3½x5	"	"	"	"	"		⅝" ADV.			8°	7°	55°	42°	.004-.006	.028	.018
HUPMOBILE	N-R&L	4	3¾x5½	"	RF	LR	LF	RR	PLACE SPARK LEVER HALF WAY	3/32IN			5°	0°	39°	24°	.004	.020	.012
JACKSON	348-A	8	2⅞x4¾	FERRO															
** JEFFERY	4	4	3¾x5¼	OWN	RR	RF	LR	LF			TR		8°	8°					
** JEFFERY	671	6	3½x5¼	"	"	"	"	"			TR		8°	8°	40°	40°	.003	.025	.020
KING	E8	8	3x5	"	LR	RF	RR	LF			TR		6°	0°			.004	.025	.012
† LOCOMOBILE	M7	6	4½x5½	"	LF	LR	RF	RR	SEE	INDEX							.004	.028	.017
† LOCOMOBILE	R7	6	4¼x5	"	"	"	"	RR	"	"			16°27'	TC	50°52'	46°22'	.004	.028	.017
MARMON	34	6	3¾x5⅛	"	LR	RF	RR	LF	"	"		A	16°27'	TC	1IN	¾IN	.004	.032	.017
MAXWELL	25	4	3⅝x4½	"	"	"	"	"	1/32"		R		T	5°			.003	.027	.006
METZ	25	4	3⅞x4	"						1 1/16"		A					.002	.020	.020
MITCHELL	C42	6	3½x5	"	RR	LF	LR	RF	ADVANCE	SPARK	¼-SET	ON TOP					.003	.035	.025
MITCHELL	D40	6	3¼x5	"	"	"	"	"	"	"	"	"					.003	.036	.025
OAKLAND	34	6	2 13/16x4¾	NORTHWAY	LR	RF	RR	LF					7½°	17½°			.003	.030	.020
OLDSMOBILE	45	8	2⅝x4¾	"	"	"	"	"	5/16"		RET		10°	15°	45°	38°	.004	.020	.015
OVERLAND	85-4	4	4⅛x4½	OWN	LR	RF	RR	LF			TR		15°	8°	46°	38°	.003	.020	.025
OVERLAND	85-6	6	3¼x4½	CONT'L.	"	"	"	"	2"		R		2½°	10°	40°	28°	.004	.020	.025
OVERLAND	88-6	6	3½x5¼	"	"	"	"	"			R		"	"	"	"	.003	.020	.025
OVERLAND	75-B	4	3⅜x5	OWN	"	"	"	"			TR		15°	8°	46°	38°	.003	.020	.025
†† PACKARD	2-35	12	3x5	"	RR	LF	LR	LF	SEE PACKARD SUPLEMENT				37/64"	1 19/64"	6 27/32"		.004	.031	.018
PAIGE	6-46	6	3½x5¼	CONT'L	LR	RF	RR	LF		¾"	RET						.005	.035	.020
PAIGE	6-38		3⅛x5		"	"	"	"									.005	.035	.020
PIERCE-ARROW	B-4	6	4½x5½	OWN	LF	LR	RF	4TH RR LF			TR		5°	5°	45°	45°	.003	.025	.012
PIERCE ARROW	A-4	6	5x7	OWN	"	"	"	" "	¼"		TR		"	"	"	"	.003	.025	.012
REO	M	6	3 9/16x5⅛	OWN	RR	LF	LR	RF	1½"		TR		1⅛"	2¼"	7"	5⅛"	.004	.031	.020
REO	R-5	4	4⅛x4½	OWN	"	"	"	"			TR		2"	2½	7½	5⅛	.004	.031	.018
SAXON	B5R	4	2¾x4	CONT'L	LR	RF	RR	LF	1"		TR		12°	12°	55°	45°	.002	.025	.020
SAXON	S4	6	2⅞x4½	"	"	"	"	"			TR		12°	12°	55°	45°	.002	.025	.020
STUDEBAKER	SF	4	3⅞x5	OWN	LR	RF	RR	LF				ADV.	SEE MARKS ON F W.				.003	.027	.015
STUDEBAKER	ED	6	3⅞x5	"	"	"	"	"	⅝IN				"	"	"		.003	.027	.015
VELIE	27	6	3½x5	CONT'L	F	R	LR	4TH LF RR	¼"		RET		2½°	10°	40°	28°	.004	.031	.015
VELIE	28	6	3¼x4½	"	RR	LF	LR	RF	¼"		RET		0°	0°	67°	33°	.004	.031	.015

Gear shift movements are abbreviated as follows: **LR**—left rear: **RF**—right forward; **RR**—right rear; **LF**—left forward. Most of the gear shifts are now as per fig. 1, page 490.

Ignition timing—assuming piston is placed on top, the position of piston is designated as after and before top—note column. **TR**—means top retarded: **R** and **RET**—retarded (see ignition timing).

Valve timing—**EC**—exhaust closes; **IO**—inlet opens; **EO**—exhaust opens; **IC**—inlet closes. Note this is expressed mostly in degrees. **TC**—means top center. Fly wheel marks usually guide one on valve timing.

Valve clearance is expressed in thousandths of an inch space also **spark plug gap** and **breaker point** gap on the ignition system, see page 541 and charts 283 and 283A for thousandths of an inch.

CHART NO. 228—Standard Adjustments of 1917 Leading Cars. For Spark Plug Sizes—see pages 239 and 612. **For Lamp Sizes and Candle Power**—see page 434.

*Not correct, see page 497. **Now as fig. 1, page 490. †See page 500. ††See page 498.

MAKE AND MODEL	Price	No. of Cylinders	Bore and Stroke, Inches	S.A.E. H.P.	Piston Displacement Cubic Inches	High Gear Ratio	Make of Engine	Cylinder Shape	Camshaft Drive	Water Circulation	LUBRICATION		ELECTRIC SYSTEM		IGNITION		CARBURETION		Clutch Type	TRANSMISSION								RUNNING GEAR				
																				GEARSET												
											System	Type of Pump	Make	Voltage	Make	Plug	Make of Carburetor	Fuel Feed		Location	Forward Speeds	Make	Final Drive	Car Drives Through	Rear Axle Type	Make of Rear Axle	Torque Taken By	Wheelbase	Tires	Rims	Wheels	Rear Springs
Abbott 6-60	$1595	6	3½x5¼	29.4	303.1	4.30-1	Cont.	L.	H.	P.	Sp-Pr	P.	Remy	6	Remy	⅞	Stmbg	V.	D.	Unit M.	3	Muncie	Sp.B	Springs	¾F.	Salsbry	Springs	122	34x4	SS	Wd.	S-E.
Allen 41	1095	4	3¾x5	22.5	220.9	4.25-1	Own	L.	H.	T.	Cir-Sp	P.	A-Lite-2	6	Conn	⅞	Stmbg	V.	P.	Unit M.	3	Own	Sp.B	Springs	F.	Adams	Springs	112	32x3½	SS	Wd.	S-E.
American B	1595	6	3⅛x5	23.4	230.1	4.42-1	Rutnbr.	L.	H.	P.	Sp-Pr	P.	G&D-2	6	G&D	⅞	Zenith	V.	P.	Unit M.	3	Mech	Sp.B	Springs	¾F.	Salsbry	Springs	122	32x4	SS	Wd.	S-E.
Anderson 20	1465	6	3¼x4½	25.3	224.0	4.58-1	Cont.	L.	H.	P.	Sp-Pr	P.	West-2	6	Conn	⅞	Zenith	V.	D.	Unit M.	3	Drstn	Sp.B	Springs	¾F	Clumba	Springs	120	33x4	SS	Wd.	S-E.
Anderson 400-F	1925	6	3½x5¼	29.4	303.1	....	Cont.	L.	H.	P.	Sp-Pr	P.	West	6	Bosch	⅞	Stmbg	V.	D.	Unit M.	...	G-Lees	Sp.B	Springs	¾F.	Clumba	Springs	120	33x4	SS	Wr.	S-E.
Apperson 8-18	2550	8	3¼x5	33.8	331.8	4.25-1	Own	L.	H.	T.	Sp-Pr	G.	Bijur-2	6	Remy	⅞	Johnson	V.	D.	Amid	3	Own	Sp.B	Springs	SF.	Own	Springs	130	34x4	SS.	Wd.	¾ Ell.
Apperson 8th Anniversary	3500	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	....	32x4½	....	Wr.	....
Auburn 6-39	1345	6	3¼x4½	25.3	224.0	4.42-1	Cont.	L.	H.	P.	Sp-Pr	P.	Remy-2	6	Remy	⅞	Rayfld	V.	P.	Unit M.	3	G-Lees	Sp.B	Springs	¾F.	....	Tor.A.	120	34x4	SS	Wd.	S-E.
Auburn 6-44	1685	6	3½x5¼	29.4	303.1	4.08-1	Cont.	L.	H.	P.	Sp-Pr	P.	Delco-2	6	Delco	⅞	Rayfld	V.	P.	Unit M.	3	G-Lees	Sp.B	Springs	F.	....	Tor.A.	131	35x4½	SS	Wd.	Cant.
Austin	3750	12	2⅞x5	39.7	389.5	3.75-1	Widly.	I.	H.	P.	Pr	G.	Delco-2	6	Delco	⅞	Stmbg	V.	D.	Unit M.	3	Muncie	Sp.B	Springs	F.	Own	Springs	142	34x4½	QD.	Wd.	DCant
Bell 18	995	4	3¾x4¼	22.5	187.7	....	G.B.&S.	L.	H.	T.	Cir-Sp	P.	Dynto-2	6	A.Kent.	⅞	Zenith	V.	D.	Unit M.	3	Covert	Bevl.	Tor.T.	F.	Pen	Tor.T.	114	31x4	QD.	Wd.	Cant.
Biddle H	2650	4	3¾x5⅛	22.5	226.4	4.40-1	Buda	L.	H.	T.	Cir-Sp	G.	G&D-2.	6	Eismn.	⅞	Zenith	V.	P.	Unit M.	4	Own	Sp.B	Springs	F.	Own	Springs	121	32x4	QD.	Wr.	S-E.
Bour-Davis 18A	1680	4	3¾x5	22.5	220.0	4.00-1	Cont.	I.	H.	P.	Cir-Sp	G.	West	6	West	⅞	Miller	V.	P.	Unit M.	3	Detroit	Sp.B	Springs	¾F.	Salsbry	Springs	118	32x4	QD.	Wd.	S-E.
Bour-Davis 18B	1785	6	3½x5¼	29.4	303.0	4.07-1	Cont.	L.	H.	P.	Cir-Sp	P.	West	6	West	⅞	Stmbg	V.	P.	Unit M.	3	Detroit	Sp.B	Springs	¾F.	Salsbry	Springs	118	33x4½	QD.	Wd.	S-E.
Brewster Chassis	5500	4	4 x5½	25.6	276.0	4.25-1	Own	K	C.	P.	Pr	G.	U.S.L.	12	Bosch	⅞	Zenith	V.	C.	Unit T	3	Own	Sp.B	Tor.T	F.	Own	Tor.T	125	34x4½	SS	Wd.	Cant.
Briscoe B-4-24	825	4	3 3/16x5⅛	16.3	163.0	4.23-1	Own	L.	H.	T.	Cir-Sp	P.	A-Lite	6	Conn	⅞	Buick	G.	C.	Unit X	3	Own	Bevl	Tor.A	S-F.	Own	Tor.A	104	30x3½	C.	Wd.	Ell.
Buick E-4-34, E-4-35	795	4	3⅜x4¾	18.2	170.0	4.08-1	Own	I.	H.	P.	Cir-Sp	G	Delco-1	6	Delco	⅞	Marvel.	V.	C.	Amid	3	Own	Bevl	Springs	¾F.	West-M	Springs	106	31x4	C.	Wd.	S-E.
Buick E-6-44-45	1265	6	3⅜x4½	27.3	242.0	4.08-1	Own	I.	H.	P.	Cir-Sp	G	Delco	6	Delco	⅞	Marvel.	V.	D.	Amid	3	Own	Sp.B	Tor	F.	West-M.	Tor.T	118	34x4	SS	Wd.	Cant.
Buick E-6-49	1495	6	3⅜x4½	27.3	242.0	4.61-1	Own	I.	H.	P.	Cir-Sp	G	Delco	6	Delco	⅞	Marvel.	V.	D.	Amid	3	Own	Sp.B	Tor	F.	West-M.	Tor.T	124	34x4½	SS	Wd.	Cant.
Cadillac 57	2970	8	3⅛x5⅛	31.2	314.0	4.43-1	Own	L	C.	P.	Pr	G	Delco-1	6	Delco	⅞	Own	P.	D.	Unit M.	3	Own	Sp.B	Springs	F.	Timken	Tor	125	35x5	SS	Wd.	Plat.
Case U	1875	6	3½x5¼	29.4	303.0	4.45-1	Cont.	L.	H.	P.	Sp-Pr	P.	West.	6	West.	⅞	Rayfld	V.	P.	Unit M.	3	G-Lees	Sp.B	Springs	¾-F	Clumba	Springs	125	35x4½	SS	Wd.	S-E.
Chalmers 6-30	1615	6	3¼x4½	25.3	224.0	4.75-1 5.18-1	Own	L.	C.	T.	Sp-Pr	G	West-2	6	Remy	⅞	Stmbg	V.	D.	Unit M.	3	Own	Sp.B	Springs	S-F.	Timken	Springs	117 122	32x4 34x4	SS	Wd.	S-E.
Chandler	1795	6	3½x5	29.4	289.0	4.40-1	Own	L.	C.	P.	Sp-Pr	P.	West	6	Bosch	⅞	Rayfld	V.	P.	Unit M.	3	Own	Sp.B	Springs	F.	Own	Tor.A.	123	34x4	SS	Wd.	S-E.
Chevrolet 490	685	4	3 11/16x4	21.7	171.0	3.65-1	Own	I.	H.	P.	Sp-Pr	G	A-Lite-2.	6	Remy	⅞	Zenith	G.	C.	Amid	3	Own	Sp.B	Springs	¾F.	Own	Springs	102	30x3½	C.	Wd.	Cant.
Chevrolet FA	935	4	3 11/16x5¼	21.7	224.0	4.25-1	Own	I.	H.	P.	Sp-Pr	G	A-Lite-2.	6	Remy	⅞	Zenith	V.	C.	Amid	3	Own	Sp.B.	Springs	¾F.	Own	Springs	108	33x4	SS	Wd.	Cant.
Chevrolet D4 & D5	1550	8	3⅜x4	36.4	286.9	4.25-1	Own	I.	H.	P.	Sp-Pr	G	A-Lite-2.	6	Remy	⅞	Zenith	V.	C.	Amid	3	Own	Bevel	Springs	¾F.	Own	Tor.T.	120	34x4	SS	Wd.	Cant.
Cole 870	2595	8	3½x4½	39.2	346.4	4.45-1	North.	L.	H.	P.	Pr	G	Delco-2	6	Delco	⅞	Stmbg	V	C.	Unit M.	3	North.	Sp.B	Springs	F.	Clumba	Springs	127	33x5	SS	Wd.	S-E.
Columbia C & D	1450	6	3¼x4½	25.3	224.0	4.75-1	Cont.	L.	H.	P.	Sp-Pr	P.	Remy	6	A.Kent.	⅞	Stmbg	V.	P.	Unit M.	3	Warner	Sp.B	Springs	¾F.	Timken	Tor.T.	115	32x4	SS	Opt.	Cant.
Comet C-51	1685	6	3½x5¼	29.4	303.1	4.45-1	Cont.	L.	H.	P.	Sp-Pr	P.	Dynto-2.	6	Delco	⅞	Rayfld	V.	D.	Unit M.	3	Covert	Sp.B	Springs	¾F.	Clumba	Tor.A.	125	33x4	SS	Opt.	Cant.
Commonwealth 4-40	1095	4	3½x5	19.6	192.0	4.00-1	Lycmg.	L.	H.	T.	Cir-Sp	P.	Dynto-2.	6	A.Kent.	⅞	Carter	V.	D.	Unit M.	3	Mech	Sp.B	Springs	F.	Peru	Springs	115	32x3½	SS	Opt.	¾ Ell.
Crawford 6-40	2250	6	3½x5¼	29.4	303.0	4.08-1	Cont.	L.	H.	P.	Cir-Sp	P.	West-2	....	Bosch	⅞	Stmbg	V.	P.	Unit M.	3	Own	Sp.B	....	¾F.	Timken	Springs	122½	32x4	....	Wd.	S-E.
Crow-Elkhart CE-36	995	4	3½x5	19.6	192.0	4.25-1	Own	I.	H.	T.	Cir-Sp	G	Dynto-2.	6	Conn	⅞	Zenith	V.	P.	Unit M.	3	Covert	Bevl	Springs	F.	Peru	Springs	115	32x3½	SS	Opt.	S-E.
Cunningham V	4250 6000	8	3¾x5	45.0	442.0	3.50-1 4.12-1	Own	L.	H.	P.	Pr	G	West-2	6	Delco	⅞	Stmbg	V.	D.	Unit M.	3	B-Lipe	Sp.B	Springs	F.	Timken	Tor.T.	132 142	35x5	....	Opt.	¾ Ell.
Daniels B	3500	8	3¼x5	33.8	331.8	4.45-1	Her-Sp.	L.	H.	P.	Pr	G	West-2	6	West	⅞	Zenith	V.	D.	Unit M.	3	B-Lipe	Sp.B	Springs	¾F.	Timken	Tor.T.	127	34x4½	QDR	Wd.	S-E.
Davis H, I	1585	6	3¼x4½	25.3	224.0	4.58-1	Cont.	L.	H.	P.	Sp-Pr	P.	Delco-2	6	Delco	⅞	Stmbg	V.	C.	Unit M.	3	Warner	Sp.B	Springs	¾F.	Clumba	Springs	119	34x4	SS	Wd.	S-E.
Davis J & J1	1950	6	3½x5¼	29.4	303.0	4.42-1	Cont.	L.	H.	P.	Sp-Pr	P.	Delco-2	6	Delco	⅞	Stmbg	V.	C.	Unit M.	3	Warner	Sp.B	Springs	F.	Clumba	Springs	125	34x4½	QD.	Wd.	S-E.
Dixie Flyer LS-35	1095	4	3¼x5	16.9	165.9	4.75-1	Lycmg.	L.	H.	T.	Cir-Sp	P.	Dynto-2.	6	Conn	⅞	Carter	V.	D.	Unit M.	3	G-Lees	Sp.B	Tor.T.	F.	Peru	Tor.T.	112	32x3½	SS	Wd.	¾ Ell.
Doble-Detroit D	3750	2	5 x4	20.0	314.0	1.25-1	Own	..	....	P.	Sp-Pr	P.	Wagnr-2	12	Doble	⅞	....	P.	....	....	....	S.	....	Springs	S-F.	Americ'n	Tor.A.	135	35x5	....	Wd.	S-E.
Dodge Brothers	985	4	3⅞x4½	24.0	212.3	4.17-1 3.62-1	Own	L.	H.	P.	Cir-Sp	G.	N-East-1	12	Own	⅞	Stewart	V.	D.	Unit M.	3	Own	Sp.B	Springs	F.	Own	Tor.T.	114	32x3½	SS	Opt.	¾ Ell.
Dorris 6-80	....	6	4 x5	38.4	377.0	3.50-1	Own	I.	H.	P.	Pr	G.	West-2	6	Bosch	⅞	Stmbg	V.	D.	Unit M.	3	Own	Sp.B	Springs	¾F.	Timken	Springs	132	33x5	SS	Wr.	S-E.
Dort 11	925	4	3½x5	19.6	192.0	4.00-1	Own	L.	H.	T.	Cir-Sp	P.	West-2	6	Conn	⅞	Carter	G.	C.	Unit M.	3	Mech	Bevl.	Springs	¾F.	W-Weis	Tor.T.	105	30x3½	QD.	Opt.	Cant.
Douglas	2000	8	3¼x5	33.8	331.8	4.42-1	Her-Sp.	L.	H.	P.	Pr	G.	West-2	6	West	⅞	Zenith	V.	D.	Unit M.	3	G-Lees	Sp.B	Springs	F.	Clumba	Tor.A.	122	34x4	SS	Wd.	Cant.
Elcar DF	1175	4	3½x5	19.6	192.4	....	Lycmg.	L.	H.	T.	Cir-Sp	P.	Dynto-2.	6	A.Kent.	⅞	L-O.	V.	D.	Unit M.	3	Mech	Sp.B	Springs	F.	Salsbry	Springs	116	32x3½	SS	Wd.	S-E.
Elcar	1295	6	3¼x4½	25.3	224.0	4.50-1	Cont.	L.	H.	P.	Sp-Pr	P.	Dynto	6	A.Kent.	⅞	Stmbg	V.	P.	Unit-M.	3	Muncie	Sp.B	Springs	F.	Salsbry	Springs	...	33x4	SS	Wd.	S-E.
Elgin F	1165	6	3x4⅝	21.6	196.2	4.45-1	Falls	I.	H.	T.	Cir-Sp	P.	Wagnr-2	6	Wagnr	⅞	Stmbg	V.	P.	Unit M.	3	Mechs	Sp.B	Springs	¾F.	Adams	Tor.A.	117	33x4	....	Wd.	Cant.
Empire 50-51	1125	4	3⅞x5	24.0	235.8	4.33-1	T-Hart.	T.	H.	P.	Cir-Sp	..	A-Lite-2.	6	Conn	⅞	Stmbg	V.	P.	Unit M.	3	Mechs	Bevl	Springs	¾F.	Peru	Tor.T.	115	33x4	SS	Opt.	S-E.
Empire 70A	1345	6	3¼x4½	25.3	224.0	4.58-1	Cont.	L.	H.	P.	Sp-Pr	P.	A-Lite-2.	6	Conn	⅞	Stmbg	V.	P.	Unit M.	3	Mechs	Sp.B	Springs	F.	Hess	Springs	120	34x4	SS	Opt.	S-E.
Essex	1395	4	3⅜x5	18.2	178.9	....	Own	..	H.	T.	Cir-Sp	P.	Delco	6	Delco	M	Own	V.	D.	....	3	Own	Sp.B	Springs	S-F.	Timken	Springs	108½	32x4	....	Wd.	S-E.

HART NO. 229—Specifications of Leading 1918 Cars—see page 546 for abbreviations.

orrections are made on pages 544 and 545 to Jan. 1919. See Index for 1919 Specifications.

MAKE AND MODEL	Price	No. of Cylinders	Bore and Stroke, Inches	S.A.E. H.P.	Piston Displacement Cubic Inches	High Gear Ratio	Make of Engine	Cylinder Shape	Camshaft Drive	Water Circulation	LUBRICATION		ELECTRIC SYSTEM		IGNITION		CARBURETION		Clutch Type	TRANSMISSION								RUNNING GEAR				
											System	Type of Pump	Make	Voltage	Make	Plug	Make of Carburetor	Fuel Feed		GEARSET Location	GEARSET Forward Speeds	GEARSET Make	Final Drive	Car Drives Through	Rear Axle Type	Make of Rear Axle	Torque Taken By	Wheelbase	Tires	Rims	Wheels	Rear Springs
Fiat E-17	$5500	4	5¼x6¾	44.1	584.0	3.75-1	Own	L.	C.	P.	Sp-Pr	G.	West-3	6	Bosch	⅞	Own	P.	D.	Amid	4	Own	Sp.B.	Tor.T.	S-F.	Own	Tor.T.	140	35x5	QD.	Wd.	S-E.
Ford T	450	4	3¾x4	22.5	176.7	3.64-1	Own	L.	S.	T.	Sp-Gr	..	Own	12	Own	½	Hol-Kng	G.	D.	Unit M.	2	Own	Bevl.	Tor.T.	S-F.	Own	Tor.T. Rad.Rd	100	30x3½	C.	Wd.	Trans.
Franklin 9	2450	6	3¼x4	25.3	199.1	4.33-1	Own	I.	H.	A.	Pr	G.	Dynto-1	12	A.Kent.	⅞	Own	V.	D.	Amid	3	Own	Sp.B.	Springs	¾-F.	Own	Springs	115	33x4½	SS.	Wd.	Ell.
F.R.P. 45-B	7000	4	4⅝x6⅝	33.8	445.0	3.00-1	Own	I.	H.	P.	Sp-Pr	P.	Bosch-3	12	Bosch	M	Stewart	P.	D.	Amid	4	Own	Bevl.	Springs	F.	Own	Tor.T.	140	36x5	..	Wr.	S-E.
Glide 6-40	1495	6	3⅛x5	23.4	230.1	4.64-1	Rutnbr.	L.	H.	P.	Sp-Pr	P.	West-2	6	West.	⅞	Rayfld	V.	D.	Unit M.	3	Own	Sp.B.	Springs	¾ F.	Amer	Springs	119	34x4½	SS.	Wd.	¾ Ell.
Grant G	1095	6	3 x4½	21.6	180.2	4.50-1	Own	I.	H.	T.	Cir-Sp.	P.	Wagnr-2	6	Remy	⅞	Stmbg.	V.	C.	Unit M.	3	Durstn	Bevl.	Tor.T.	F.	Peru	Tor.T.	114	32x3½	SS.	Wd*	Cant.
Hackett Four AL	985	4	3¾x4¼	22.5	187.7	4.00-1	Own	L.	C.	T.	Sp-Pr	P.	Dynto	6	Conn	⅞	Buick	V.	D.	Unit M.	3	G-Lees	Bevl.	Springs	S-F.	W-Weiss	Springs	112	32x3½	.....	Wd.	¾ Ell.
Halladay S	1385	6	3⅛x 5	23.4	230.1	.....	Rutnbr.	...	...	...	...	...	West.	....	A-Lite	....	Zenith	V.	D.	.....	3	G-Lees	.....	.....	.....	Hess	.....	120	34x4	SS.	...	.....
Halladay R	1575	6	3⅛x5	23.4	230.1	.....	Rutnbr.	...	...	...	...	...	West.	....	A-Lite	....	Zenith	V.	D.	.....	3	G-Lees	.....	.....	.....	Hess	.....	122	34x4	SS.	...	.....
Harroun A-1	995	4	3¼x5¼	16.9	174.2	4.00-1	Own	L.	H.	T.	Cir-Sp.	P.	Remy-2	6	A.Kent.	⅞	Stmbg.	V.	C.	Unit M.	3	Mech.	Bevl.	Springs	¾ F.	Own	Tor.T.	106	30x3½	....	Wd.	Cant.
Harvard 4-30	985	4	3 x4¼	14.4	120.2	4.00-1	Sterl.	I.	H.	T.	Cir-Sp.	G.	Wagnr-2	6	A.Kent.	⅞	Zenith	G.	C.	Unit M.	3	Dtroit	Bevl.	Tor.A.	S-F.	Detroit	Springs	100	28x3	....	Opt.	Cant.
Haynes 38	1850	6	3½x5	29.4	288.6	4.42-1	Own	L.	H.	P.	Cir-Sp.	P.	Leo-N-2	6	Remy	⅞	Rayfld	V.	P.	Unit M.	3	Own	Sp.B.	Springs	¾ F.	Own	Springs	121	34x4	SS.	Wd.	S-E.
Haynes 39	1950	6	3½x5	29.4	288.6	4.42-1	Own	L.	H.	P.	Cir-Sp.	P.	Leo-N-2	6	Remy	⅞	Rayfld	V.	P.	Unit M.	3	Own	Sp.B.	Springs	¾ F.	Own	Springs	127	35x4½	SS.	Wd.	S-E.
Haynes 44	2910	12	2¾x5	36.3	356.3	4.07-1	Own	I.	C.	P.	Pr	G.	Leo-N-2	6	Delco	⅞	Rayfld	V.	P.	Unit M.	3	Own	Sp.B.	Springs	¾ F.	Own	Springs	127	34x4½	SS.	Wr.	S-E.
Hollier 188	1385	8	3 x4¼	28.8	240.3	4.50-1	Own	L.	H.	T.	Pr	G	Split-1	12	A.Kent.	⅞	Stewrt.	V.	C.	Unit M.	3	Own	Sp.B.	Tor.T.	F.	Own	Tor.T.	116	34x4	SS.	Wd.	Cant.
Hollier 206	1485	6	3¼x4½	25.3	224.0	4.58-1	Cont.	L.	H.	P.	Sp-Pr	G	Split	12	Remy	⅞	Stmbg.	V.	C.	Unit M.	3	Own	Sp.B.	....	F.	Own	Tor.T.	116	32x4	SS.	Wd.	Cant.
Hudson Super-Six	1950	6	3½x5	29.4	288.6	4.45-1	Own	L.	H.	P.	Cir-Sp.	P.	Delco-1	6	Delco	⅞	Own	V.	D.	Unit M.	3	Own	Sp.B.	Springs	¾-F.	Timken	Springs	125½	35x4½	SS.	Wd*	S-E.
Hupmobile R	1350	4	3¼x5½	16.9	182.5	4.91-1	Own	L.	C.	T.	Pr	G	Bijur	6	A.Kent.	⅞	Stmbg.	V.	D.	Unit M.	3	Own	Sp.B.	Springs	¾ F.	Own	Springs	112	32x4	SS.	Wd.	S-E.
Inter-State T	1000	4	3½x5	19.6	192.4	4.00-1	Beaver	I.	H.	T.	Cir-Sp.	G.	Remy-2	6	Remy	⅞	Schblr.	G.	C.	Unit X.	3	Drstn	Bevl.	Tor.T.	¾ F.	Peru	Tor.T.	110	33x4	SS.	Wd.	¾ Ell.
Jackson 349	1495	8	3 x3½	28.8	197.9	5.27-1	Ferro	I.	H.	T.	Pr	G.	A-Lite-2	6	Remy	⅞	Zenith	V.	P.	Unit M.	3	Covert	Sp.B.	Springs	¾ F.	Salsbry.	Springs	118	34x4	SS.	Wd.	Ell.
Jones 27-ABC	1875	6	3½x5⅛	29.4	295.9	4.45-1	Cont.	L.	H.	P.	Cir-Sp.	P.	West.	6	Remy	⅞	Rayfld	V.	P.	Unit M.	3	Covert	Sp.B.	Springs	¾ F.	Timken	Springs	126	34x4	SS.	Wd.	S-E.
Jordan J-60	1995	6	3½x5¼	29.4	303.1	4.08-1	Cont.	L.	H.	P.	Sp-Pr	P.	Bijur-2	6	Delco	⅞	Stmbg.	V.	D.	Unit M.	3	Detroit	Sp.B.	Springs	S-F.	Timken	Springs	127	33x4½	SS.	Wd.	S-E.
King F	2150	8	3 x5	28.8	282.7	4.58-1	Own	L.	C.	T.	Pr	G.	Bijur-2	6	A.Kent.	⅞	Ball	V.	P.	Unit M.	3	Own	Sp.B.	Springs	F.	Clumba.	Tor.A.	120	34x4	SS.	Wd.	Cant.
Kissel Hundred Pt. Six	1495	6	3¼x5	25.3	248.9	4.58-1	Own	L.	H.	P.	Sp-Pr	G.	Remy	6	Remy	⅞	Stmbg.	V.	C.	Unit M.	3	TWWarner	Sp.B.	Springs	F.	Own	Springs	117	34x4	SS.	Wd.	¾ Ell.
Kissel Double Six	2450	12	2⅞x5	39.6	259.0	4.58-1	Widly.	I.	H.	P.	Pr	G.	Delco	6	Delco	⅞	Stmbg.	V.	D.	Unit M.	3	Warner Gr.	Sp.B.	Springs	F.	Own	Springs	128	34x4½	SS.	Wd.	¾ Ell.
Kline 6-38	1595	6	3¼x4½	25.3	224.0	4.75-1	Cont.	L.	H.	P.	Sp-Pr	P.	West-2	6	West.	⅞	Rayfld	V.	P.	Unit M.	3	G-Lees	Sp.B.	Springs	F.	Hess	Springs	120	34x4	SS.	Wd.	¾ Ell.
Lexington 6-R	1585	6	3¼x4½	25.3	224.0	5.00-1	Cont.	L.	H.	P.	Cir-Sp.	P.	West-2	6	Conn	⅞	Rayfld	V.	P.	Unit M.	3	Warner	Sp.B.	Springs	¾ F.	Hess	Springs	122	34x4	QD.	Wd.	S-E.
Liberty 10-B	1485	6	3¼x4½	25.4	224.1	4.75-1	Cont.	L.	H.	T.	Sp-Pr	P.	Delco-2	6	Delco	⅞	Stmbg.	V.	P.	Unit M.	3	Detroit	Sp.B.	Springs	S-F.	Timken	Springs	115	32x4	SS.	Wd.	S-E.
Locomobile 2-38	5000	6	4¼x5	43.3	425.6	4.07-1	Own	T.	H.	P.	Sp-Pr	G.	West-3	6	Berling.	⅞	Ball	P.	D.	Amid	4	Own	Sp.B.	Rad.Rd	F.	Own	Tor.A.	139	37x5	QD.	Wd.	¾ Ell.
Locomobile 2-48	5950	6	4½x5½	48.6	524.8	3.25-1	Own	T.	H.	P.	Sp-Pr	G.	West-3	6	Berling.	⅞	Ball	P.	D.	Amid	4	Own	Sp.B.	Rad.Rd	F.	Own	Tor.A.	142	37x5	QD.	Wd.	¾ Ell.
Madison	1485	6	3⅛x5	23.4	230.1	4.64-1	Rutnbr.	L.	H.	P.	Sp-Pr	P.	Remy	6	Remy	⅞	Rayfld	V.	D.	Unit M.	3	Muncie	Sp.B.	Springs	¾ F.	Salsbry.	Springs	120	34x4	.....	Wd.	¾ Ell.
		6	3⅛x5	23.4	230.1	4.42-1	Rutnbr.	L.	H.	P.	Cir-Sp.	P.	Remy-2	6	Remy	⅞	Rayfld	V.	D.	Unit M.	3	Muncie	Sp.B.	Springs	¾ F.	Salsbry.	Springs	120	34x4	SS.	Wd.	¾ Ell.
Maibohm A	830	4	3⅛x4	15.6	122.7	4.25-1	Own	L.	H.	T.	Sp-Pr	P.	Disco-1	12	A.Kent.	⅞	Zenith	G.	D.	Unit M.	3	Mech	Sp.B.	Springs	F.	W-Weiss	Springs	105	30x3½	C.	Opt.	S-E.
Maibohm B	1150	6	3⅛x4¼	23.4	195.6	4.50-1	Falls	I.	H.	T.	Sp-Pr	P.	Wagnr-2	6	A.Kent.	⅞	Stmbg.	V.	P.	Unit M.	3	Mech	Sp.B.	Springs	F.	Peru	Springs	115	32x3½	SS.	Opt.	S-E.
Marmon 34	3750	6	3¾x5⅜	33.7	339.7	3.60-1 4.00-1	Own	I.	H.	P.	Pr	G.	Bijur-3	6	Bosch	⅞	Stmbg.	G.	C.	Unit T.	3	Own	Sp.B.	Tor.T.	¾ F.	Own	Tor.T.	136	32x4½	QD.	Wr.	Brush.

Corrections: Some few cars have changed model numbers and many have changed prices as follows: Abbott model 6-62 otherwise same as 6-60; Allen—41, $1195; American—B, now uses West 2 electric system, At-K. ignition, Zenith carburetor; Apperson—8-18, now $2800; Auburn—6-39, $1440; Auburn—6-44, $1795; Bell—18, $1150 and Stromb. carburetor; Biddle—H, $2750; Cadillac—57, $3220; Chevrolet—490, $785; Chevrolet—FA, $995; Chevrolet—D4-D5, $1585; Columbia—C-D, $1550, W. Lord. elect. system; Crawford—6-40, $2500; Crow-Elkhart—CE 36, $1095; Davis—H, I, L, $1685; Davis—J-M, $2050; Elcar, $1875; Empire 72, [illegible] as 70A, $1445; Ford—T, $525; Glide—6-40, $1655; Grant—G, $1245; Jordan—J-60, $2575; Kissel double six, $2605; Kline—6-38, $1695; Lexington—6-O, $1485; Lexington—6-R, $1685; Lozier—84, [illegible]

See page [illegible] for meaning of abbreviations. [illegible]

CHART NO. 280—Specifications of Leading 1918 Cars, with Corrections to Jan., 1919.

MAKE AND MODEL		Price	No. of Cylinders	Bore and Stroke, Inches	S.A.E. H.P.	Piston Displacement Cubic Inches	High Gear Ratio	Make of Engine	Cylinder Shape	Camshaft Drive	Water Circulation	LUBRICATION		ELECTRIC SYSTEM		IGNITION		CARBURETION		Clutch Type
												System	Type of Pump	Make	Voltage	Make	Plug	Make of Carbureter	Fuel Feed	
Maxwell	25	825	4	3⅝x4½	21.0	185.8	3.58-1	Own	L.	H.	T.	Sp-Pr	P.	S-Huff-1.	12	A.Kent.	⅞	K-D	G.	C.
McFarlan	X	3900	6	4½x6	48.6	572.5	3.50-1	Teetor	T.	H.	P.	Sp-Pr	P.	West-2	6	Eismn.	⅞	Stmbg.	V.	P.
Mercer	Series 4	3850	4	3¾x6¾	22.5	298.2	3.22-1 3.62-1	Own	L.	C.	P.	Pr.	G.	West	12	Berlin	⅞	Ball	V.	D.
Metz	25	605	4	3⅞x4	24.0	188.7	4.00-1	Own	L.	H.	T.	Cir-Sp.	G.	West-2	6	A.Kent.	½ L	A.W.T.	G.	...
Mitchell	D-40	1350	6	3¼x5	25.3	248.9	4.25-1	Own	L.	H.	P.	Sp-Pr	P.	Remy	6	Remy	⅞	Rayfld	V.	C.
Mitchell	C-42	1625	6	3½x5	29.4	288.6	4.25-1	Own	L.	H.	P.	Sp-Pr	P.	Remy	6	Remy	⅞	Stmbg.	V.	C.
Moline-Knight	C	1750	4	3¾x5	22.5	220.9	4.90-1	Own	K	C.	T.	Pr.	G.	A-Lite	6	Conn	⅞	Schblr.	V.	C.
Moline-Knight	G	2375	4	4 x6	25.6	301.6	4.00-1	Own	K	C.	T.	Pr.	G.	A-Lite	6	Conn	⅞	Schblr.	V.	C.
Monitor	J	1295	6	3¼x4½	25.4	224.0	4.08-1 4.50-1	Cont.	L.	H.	P.	Sp-Pr		Dyneto	6	Conn	⅞	Stmbg.	V.	P.
Monroe	Club M-3	635	4	3 x4½	14.4	120.2	4.00-1	Sterl.	I.	H.	T.	Cir-Sp.	P.	A-Lite-2.	6	Conn	⅞	Zenith	V.	D.
Monroe	M-6	995	4	3¼x4½	16.9	149.3	4.80-1	Own	I.	H.	T.	Sp-Pr	G.	A-Lite-2.	6	Conn	⅞	Zenith	V.	D.
Moon	6-36	1395	6	2⅞x4¼	19.8	165.5	4.75-1	Cont.	L.	H.	T.	Sp-Pr	P.	Wagnr-2	6	Delco	⅞	Tiltsn	G.	P.
Moon	6-66	2250	6	3½x5¼	29.4	303.1	4.45-1	Cont.	L.	H.	P.	Sp-Pr	P.	Delco-2	6	Delco	⅞	Rayfld	V.	P.
Moore	30	795	4	3¾x4¼	22.5	187.7	4.50-1	G.B.&S.	L.	H.	T.	Sp-Pr	..	A-Lite	6	Conn	⅞	K.P.	V.	D.
Murray	70-T	2800	8	3¼x5	33.8	331.8	4.08-1 4.45-1	Her-Sp.	L.	H.	P.	Pr.	G.	West-2	6	Conn	⅞	Zenith	V	P.
Nash	682 681-683	1545 1395	6	3¼x5	25.3	249.0	4.50-1	Own	I.	H.	P.	Sp-Pr	G.	Delco	6	Delco	⅞	Marvel	V.	P.
National	6	2450	6	3½x5¼	29.4	303.1	4.58-1	Own	L.	H.	P.	Sp-Pr	P.	West-2	6	Spltdf.	⅞	Rayfld	V.	C.
National	12	3050	12	2⅞x4¾	39.6	370.1	4.58-1	Own	L.	H.	P.	Pr.	G.	Bijur-2	6	Delco	⅞	Rayfld	V.	C.
Nelson		1400	4	3⅛x4¾	15.6	145.7	4.25-1	Own	I.	H.	T.	Pr.	G.	U.S.L.-1.	12	Bosch	⅞	Zenith	V.	D.
Oakland	34-B	$1050	6	2{13/16}x4¾	19.0	177.0	4.50-1	North	I	H.	P.	Pr	G.	Remy-2	6	Remy	⅞	Marvel.	V.	C.
Oldsmobile	37	1295	6	2{13/16}x4¾	19.0	177.0	4.58-1	North	I	H.	P.	Pr	G.	Remy-2	6	Remy	⅞	Johnsn	V.	C.
Oldsmobile	45-A	1550	8	2⅞x4¾	26.4	246.7	4.92-1	Own	L.	H.	P.	Pr.	G.	Delco-2	6	Delco	⅞	Ball	V.	C.
Olympian		1085	4	3¼x4½	16.9	149.3	4.75-1	Own	I	H.	T.	Pr.	G.	A-Lite-2	6	Conn	...	Stmbg.	V.	D.
Overland	90	850	4	3⅜x5	18.2	178.9	4.00-1	Own	L.	H.	T.	Cir-Sp.	P.	A-Lite-2	6	Conn	⅞	Tilltsn	V.	C.
Overland	85-B-4	965	4	4⅛x4½	27.2	240.5	4.00-1	Own	L.	H.	T.	Cir-Sp.	G.	A-Lite-2	6	Conn	⅞	Tilltsn	V.	C.
Overland	85-B-6	1195	6	3¼x4½	25.3	224.0	4.60-1	Cont.	L.	H.	P.	Sp-Pr	P.	A-Lite	6	Conn	⅞	Tilltsn	V.	C.
Owen Magnetic	W-42	5300	6	4 x5½	38.4	414.7	4.00-1	Own	I	Sp-G	P.	Pr.	G.	Own	24	Bosch	⅞	Zenith	V.	Om
Owen Magnetic	M-25	3300	6	3½x5¼	29.4	303.1	4.08-1	Cont.	L.	H.	P.	Sp-Pr	P.	Own	14	Bosch	⅞	Zenith	V.	Om
Owen Magnetic	O-36	3950	6	3¾x5½	33.6	364.5	3.50-1	Buda	L.	H.	P.	Sp-Pr	G.	Own	28	Bosch	⅞	Zenith	V.	Om
Packard	3-25 3-35	3950 4300	12	3 x5	43.2	424.1	4.36-1	Own	L.	C.	P.	Pr.	G.	Bijur-2	6	Delco	⅞	Own	P.	D.
Paige	6-39	1395	6	3⅛x5	23.4	230.1	4.41-1	Rutnbr.	L.	H.	P.	Sp-Pr	P.	G&D-2.	6	Remy	⅞	Stmbg.	G.	P.
Paige	6-55	1830	6	3½x5¼	29.4	303.1	4.35-1	Cont.	L.	H.	P.	Sp-Pr	P.	Remy-2	6	Remy	⅞	Rayfld	V.	P.
Pan-American	G-5	1650	6	3⅛x5	23.4	230.0	4.45-1	Rutnbr.	L.	H.	P.	Sp-Pr	P.	G&D	6	G&D	⅞	Rayfld	V.	P.
Paterson	6-45	1495	6	3¼x4½	25.4	224.0	4.50-1	Cont.	L.	H.	P.	Sp-Pr	P.	Delco	6	Delco	⅞ L	Stmbg.	V.	D.
Peerless	56	2550	8	3¼x5	33.8	331.8	4.90-1	Own	L.	H.	P.	Pr.	G.	A-Lite-2.	6	A.Kent.	⅞	Ball	V.	D.
Pierce-Arrow	C-4	4800	6	4 x5½	38.4	414.7	3.78-1	Own	T.	H.	P.	Pr.	G.	West-2	6	Bosch	⅞	Own	P.	C.
Pierce-Arrow	B-4	5500	6	4½x5½	48.6	524.8	3.53-1	Own	T.	H.	P.	Pr.	G.	West-2	6	Bosch	⅞	Own	P.	C.
Pierce-Arrow	A-4	6500	6	5 x7	60.0	824.7	2.88-1	Own	T.	H.	P.	Pr.	G.	West-2	6	Bosch	⅞	Own	P.	C.
Pilot	6-45	1395	6	3⅛x5	23.4	230.1	4.25-1	T-Hart.	L.	H.	P.	Sp-Pr	P.	Delco-2	6	Delco	⅞	Tiltsn	V.	P.
Premier	6-C	2285	6	3⅜x5½	27.3	295.3	4.45-1	Own	L.	H.	P.	Sp-Pr	G.	Delco-2	6	Delco	⅞	Johnson	V.	P.

MAKE AND MODEL		TRANSMISSION								RUNNING GEAR				
		GEARSET			Final Drive	Car Drives Through	Rear Axle Type	Make of Rear Axle	Torque Taken By	Wheelbase	Tire	Rims	Wheels	Rear Springs
		Location	Forward Speeds	Make										
Maxwell	25	Unit M.	3	Own	Bevl.	Springs.	¾ F.	Own	Tor.T.	109	30x3½	C.	Opt.	S-E.
McFarlan	X	Amid	3	B-Lipe	Sp.B.	Springs.	F.	Timken	Springs.	136	35x5	QD.	Opt.	S-E.
Mercer	Series 4	Amid	4	Own	Sp.B.	Springs.	F.	Own	Springs.	115 132	32x4 32x4½	SS.	Wr.	S-E.
Metz	25	Amid	7	Friction	Chain.	Rad.Rd.	D.	Own	Springs.	108	32x3½	SS.	Opt.	Ell.
Mitchell	D-40	Unit T.	3	Own	Sp.B.	Springs.	¾ F.	Own	Tor.T.	120	32x4	SS.	Wd.	Cant.
Mitchell	C-42	Unit T.	3	Own	Sp.B.	Springs.	F.	Own	Tor.T.	127	34x4	SS.	Wd.	Cant.
Moline-Knight	C	Amid	3	Warner	Sp.B.	Tor.A.	S-F.	Timken	Tor.A.	118	34x4	SS.	Wd.	Brush.
Moline-Knight	G	Amid	3	Warner	Sp.B.	Tor.A.	S-F.	Timken	Tor.A.	122	35x4½	SS.	Wd.	Brush.
Monitor	J	Unit M.	3	G-Lees	Bevl.	Springs.	F.	Adams	Springs.	117	33x4	SS.	Wd.	¾ Ell.
Monroe	Club M-3	Unit M.	3	Mech	Sp.B.	Springs.	¾ F.	W-Weiss	Springs.	96	31x3½	QD.	Wd.	S-E.
Monroe	M-6	Unit M.	3	Mech	Sp.B.	Tor.A.	S.F.	Hess	Tor.T.	115	32x3½	QD.	Opt.	Brush.
Moon	6-36	Unit X.	3	Jacobson	Sp.B.	Tor-A.	S.F.	Jacobson	Tor.T.	114	32x3½	SS.	Wd.	S-E.
Moon	6-66	Unit M.	3	Warner	Sp.B.	Springs.	S-F.	Timken	Springs.	125	35x4½	SS.	Wd.	S-E.
Moore	30	Unit M.	3	G-Lees	Sp.B.	Springs.	F.	Salsbry	Springs.	106	30x3½	C.	Wd.	¾ E.
Murray	70-T	Unit M.	3	Covert	Sp.B.	Springs.	F.	Timken	Springs.	128	34x4½	.....	Opt.	¾ Ell.
Nash	682 681-683	Unit M.	3	Own	Sp.B.	Springs.	S-F.	Own	Springs.	127 121	34x4	SS.	Wd.	S-E.
National	6	Unit M.	3	Muncie	Sp.B.	Springs.	F.	Clumba.	Tor.A.	128	34x4½	QDR	Wd.	Cant.
National	12	Unit M.	3	Muncie	Sp.B.	Springs.	F.	Clumba.	Tor.A.	128	34x4½	QDR	Wd.	Cant.
Nelson		Unit X.	3	Own	Sp.B.	Sub-Fr.	F.	Own	Rad-Rd.	104	32x4	SS.	Wd.	Trans.
Oakland	34-B	Unit M.	3	Warner	Bevel	Springs.	F.	West.M	Springs.	112	32x4	SS.	Wd.	S-E.
Oldsmobile	37	Unit M.	3	North	Sp.B.	Springs.	F.	West.M	Springs.	112	32x4	SS.	Wd.	S-E.
Oldsmobile	45-A	Unit M.	3	Own	Sp.B.	Springs.	F.	West.M	Springs.	120	34x4	SS.	Wd.	¾ Ell.
Olympian		Unit X.	3	Own	Sp.B.	Springs.	¾ F.	Own	Rad.Rd	112	32x3½	.....	Opt.	Trans.
Overland	90	Unit X.	3	Own	Sp.B.	Tor.T.	¾ F.	Own	Tor.T.	106	31x4	C.	Wd.	Cant.
Overland	85-B-4	Unit X.	3	Own	Bevel	Tor.T.	¾ F.	Own	Tor.T.	112	32x4	SS.	Wd.	Cant.
Overland	85-B-6	Unit X.	3	Own	Sp.B.	Tor.T.	¾ F.	Own	Tor.T.	116	32x4	C.	Wd.	Cant.
Owen Magnetic	W-42	Unit M.	.	Magnetic	Sp.B.	Springs.	F.	Amer	Springs.	142	35x5	SS.	Wr.	S-E.
Owen Magnetic	M-25	Unit M.	.	Magnetic	Sp.B.	Springs.	¾ F.	Timken	Springs.	125	34x4½	SS.	Wd.	S-E.
Owen Magnetic	O-36	Unit M.	.	Magnetic	Sp.B.	Springs.	F.	Amer	Tor.T.	136	35x5	SS.	Wr.	S-E.
Packard	3-25 3-35	Unit M.	3	Own	Sp.B.	Springs.	S-F.	Own	Tor.A.	128 136	35x5	QD.	Wd.	S-E.
Paige	6-39	Unit M.	3	Own	Sp.B.	Tor.T.	¾ F.	Salsbry.	Tor.T.	117	32x4	SS.	Wd.	Cant.
Paige	6-55	Unit M.	3	Own	Sp.B.	Tor.T.	¾ F.	Salsbry.	Tor.T.	127	35x4½	SS.	Wd.	Cant.
Pan-American	G-5	Unit M.	3	Warner	Sp.B.	Springs.	S-F.	Timken	Springs.	120	33x4½	SS.	Wd.	S-E.
Paterson	6-45	Unit M.	3	Drstn.	Sp.B.	Springs.	F.	Hess	Springs.	120	34x4	C.	Wd.	¾ Ell.
Peerless	56	Unit M.	3	B-Lipe	Sp.B.	Springs.	S-F.	Timken	Springs.	125	35x4½	SS.	Wd.	Plat.
Pierce-Arrow	C-4	Amid	4	Own	Sp.B.	Springs.	S-F.	Own	Tor.T.	134	34x4½	QD.	Wd.	¾ Ell.
Pierce-Arrow	B-4	Amid	4	Own	Sp.B.	Springs.	S-F.	Own	Tor.T.	142	35x5	QD.	Wd.	¾ Ell.
Pierce-Arrow	A-4	Amid	4	Own	Sp.B.	Springs.	S-F.	Own	Tor.T.	147½	36x5½	QD.	Wd.	¾ Ell.
Pilot	6-45	Unit M.	3	Muncie	Sp.B.	Springs.	¾ F.	Hess	Tor.A.	120	32x4	SS.	Wd.	Cant.
Premier	6-C	Unit M.	3	Detroit	Sp.B.	Springs.	S-F.	Timken	Springs.	125½	35x4½ 32x4½	SS.	Wd.	S-E.

—continued from page 544.

—760, $1650, 6 cyl., 3¾x5¼; Maibohm—B, $1260; Maxwell—25, now uses Johnson carburetor; Mercer—4, $4000; Moline-Knight—C, $1850; Moline-Knight—G, $2500; Oakland—34B, $1185; Olds—37, $1395; Olds—45A, $1700; Olympian, $1240; Overland—90B, $895; Overland—85-B-4, $1025; Overland—85-B-6, $1300; Packard—3-25, $4350; Packard—3-35, $4600; Paige—6-39, $1515; Paige—655, $1985; Pan Am.—G-5, $1800; Patterson—6-46, $1595; Premier—6-C, $2585; Revere, $3850; Roamer—D-4-75, $3250; Roamer—C-6-54, $2475; Sayers—6-42, $1495; Scripps-Booth—G, 4 cyl., $935; Scripps Booth—D, 8 cyl., $1285; Stephens—6, $1725; Studebaker—E G, $1985; Studebaker—E H 6-50, $1585; Sun—17, $1500; Templer, $2185; Velie—38, $1440; Velie—39, $1695; Westcott—S-18A, $2490; Willys-Knight — 88-4, $1675; Willys-Knight — 88-8, $2500; Willys—89, $1525.

See page 546 for meaning of abbreviations.

CHART NO. 231—Specifications of Leading 1918 Cars with Corrections to Jan. 1919.

(Motor World.) See index for 1919 Specifications and change of prices.

MAKE AND MODEL	Price	No. of Cylinders	Bore and Stroke, Inches	S.A.E. H.P.	Piston Displacement Cubic Inches	High Gear Ratio	Make of Engine	Cylinder Shape	Camshaft Drive	Water Circulation	LUBRICATION		ELECTRIC SYSTEM		IGNITION		CARBURETION		Clutch Type	TRANSMISSION								RUNNING GEAR				
																				GEARSET												
											System	Type of Pump	Make	Voltage	Make	Plug	Make of Carburetor	Fuel Feed		Location	Forward Speeds	Make	Final Drive	Car Drives Through	Rear Axle Type	Make of Rear Axle	Torque Taken By	Wheelbase	Tire	Rims	Wheels	Rear Springs
Princess 36-F	875	4	3¾x4¼	22.5	187.7	4.25-1	G.B.&S.	L.	C.	T	Cir-Sp.	P.	Disco-2	6	Splitdrf.	⅞	Schblr.	V.	D.	Unit M.	3	G-Lees	Sp.B.	Springs	F.	Own	Springs	108	32x3½	......	Wd	¾ Ell
Regal .... J	795	4	3½x4¾	19.6	182.8	4.25-1	Own	L.	H.	T.	Cir-Sp.	P.	A-Lite	6	A.Kent.	⅞	Carter	V.	C.	Unit M.	3	G-Lees	Bevel	Tor.T.	F.	Peru	Tor.T.	108	30x3½	QD	Wd.	Cant.
Reo .... T	1295	4	4⅛x4½	27.2	240.5	4.30-1	Own	F.	H.	P.	Cir-Sp.	P.	Remy-2	6	Remy	½ L	Johnson	V.	D.	Amid	3	Own	Sp.B.	Springs	S-F.	Own	Springs	120	34x4	SS	Wd.	S-E.
Reo .... M	1550	6	3⁹⁄₁₆x5⅛	30.4	306.6	4.30-1	Own	F.	H.	P.	Cir-Sp.	P.	Remy-2	6	Remy	½ L	Rayfld	V.	D.	Amid	3	Own	Sp.B.	Springs	F.	Own	Tor.A.	126	34x4½	SS	Wd	Cant.
Roamer D-4-75	2475	4	4 x6	25.6	301.6	3.77-1	Dusnbr.	H	H.	P.	Sp-Pr	G.	Bijur	6	Bosch	⅞	Stmbg.	V.	P.	Unit M.	3	G-Lees.	Sp.B.	Springs	¾ F.	Hess	Tor.A.	128	32x4½	SS	Wr.	S-E
Roamer C-6-54	2375	6	3½x5¼	29.4	303.1	3.77-1	Cont	L.	H.	P.	Sp-Pr	P.	Bijur	6	Bosch	⅞	Stmbg.	V.	P.	Unit M.	3	G-Lees	Sp.B.	Springs	¾ F.	Hess	Tor.A	128	32x4	SS	Wr.	S-E.
Saxon S-4	1045	6	2⅞x4½	19.8	175.3	4.75-1	Cont.	L.	H.	T.	Cir-Sp.	P.	Wagnr-2	6	Remy	⅞	Stmbg.	G.	P.	Unit X.	3	Own	Sp.B.	Tor.T.	S-F.	Timken	Tor.T.	112	32x3½	SS	Opt.	Cant.
Sayers Six-42	1395	6	3¼x4½	25.3	224.0	4.75-1	Cont	L.	...	P	Sp-Pr.	..	Delco	6	Delco	⅞	Zenith	V.	P.	Unit M.	3	Mechani-	Sp.B.	Springs	¾ F.	Hess	Springs	118	32x4	SS	Wd.	S-E.
Scripps-Booth Six-39	1195	6	2¹³⁄₁₆x4¾	19.0	177.0	4.5-1	North	I.	H	P	Sp-Pr.	G.	Remy-2	6	Remy	⅞	Marvel	V	C.	Unit M.	3	Warner	Bevel	Springs	F.	West.M	Springs	112	32x4	SS	Opt.	S-E.
Simplex V	7000	6	4⅜x6¼	45.9	563.7	3.00-1	Own	L.	C.	P.	Sp-Pr	G.	Bosch-2	12	Eismn.	⅞	Newcmb	P.	D.	Unit M.	4	Own	Sp.B	Springs	F.	Own	Springs	143½	37x5	QD	Opt.	S-E.
Singer 17	4100	6	4 x5½	38.4	414.7	3.77-1	Her-Sp	T.	H.	P.	Pr.	G.	West-1	6	Bosch	⅞	Rayfld	V.	D.	Unit M.	4	Muncie.	Sp.B	Springs	F.	Timken	Tor.T.	139	35x5	QD	Wr.	Cant.
Standard .... G	2450	8	3¼x5	33.8	331.8	4.45-1	Her-Sp.	L.	H.	P.	Pr.	G.	West-2	6	West	⅞	Zenith	V.	P.	Unit M.	3	G-Lees	Sp.B	Springs	S-F.	Timken	Springs	127	34x4½	......	Wd	S-E.
Stanley .... Steamer	2800	2	4 x5	12.8	125.6	1.5 -1	....	..			....		....	....	....	....	....	P.	..	....	..	....	Sp.G.	Rad.Rd	...	Own	Engine	130	35x4½	SS	Wd	Ell
Stearns SKL4	1935	4	3¾x5⅝	22.5	248.5	4.50-1	Own	K	C.	P.	Sp-Pr	G.	West-2	12	Remy	⅞	Schblr.	V.	D.	Unit M.	3	Own	Sp.B.	Springs	S-F.	Own	Tor.A.	119	34x4	SS	Wd.	Cant.
Stearns SK8	2700	8	3¼x5	33.8	331.8	4.75-1	Own	K	C.	T.	Sp-Pr	G.	West-2	12	Remy	⅞	Rayfld	V.	D.	Unit M.	3	Own	Sp.B.	Springs	S-F	Own	Tor.A.	125	35x4½	SS	Wd.	Cant.
Stephens .... Salient Six	1585	6	3¼x4½	25.3	224.0	4.75-1	Own	I.	H.	T.	Pr.	G.	Delco	6	Delco	⅞	Stmbg.	V.	P.	Unit M.	3	Mech	Sp.B	Springs	F.	Hess	Springs	118	32x4	SS	Wd	S-E.
Studebaker SH4-40	1125	4	3½x5	22.5	192.4	4.08-1	Own	L.	H.	P.	Cir-Sp.	G.	Wagnr-2	6	Remy	m	Schblr.	V.	C.	Amid	3	Own	Sp.B.	Springs	S-F.	Own	Springs	112	32x3½	SS	Wd	S-E.
Studebaker .... EG	1585	6	3⅞x5	36.0	354.0	3.71-1	Own	L.	H.	P.	Cir-Sp.	G.	Wagnr	6	Remy	⅞	Ball	V.	C.	Amid	3	Own	Sp.B.	Springs	S-F.	Own	Springs	126	33x4½	SS	Wd	S-E.
Studebaker EH6-50	1985	6	3½x5	29.4	288.6	4.00-1	Own	L.	H.	P	Cir-Sp.	G.	Wagnr-2	6	Remy	½	Ball	V.	C.	Amid	3	Own	Sp.B.	Springs	S-F.	Own	Springs	119	32x4	SS	Wd	S-E.
Stutz .... S	2750	4	4⅜x6	30.6	360.8	3.75-1	Own	T.	H.	P.	Pr.	G.	Remy-2	6	Delco	⅞	Stmbg.	P.	C.	Unit X.	3	Own	Bevel	Tor.T.	¾ F.	Own	Tor.T.	130	32x4½	SS	Wr.	S-E.
Templar A445	2085	4	3⅜x5½	18.2	197.0	4.81-1	Own	I.	C.	P.	Pr.	G.	Remy-2	6	Remy	⅞	Zenith	V.	P.	Unit M	3	Detroit	Sp.B.	Springs	S-F.	Amer	Springs	118	32x4	SS	Wd.	S-E.
Velie 38	1390	6	3¼x4½	25.3	224.0	4.75-1	Cont.	L.	H.	P.	Sp-Pr	P.	Remy-2	6	Remy	⅞	Rayfld	V.	P.	Unit M.	3	Durstn.	Sp.B.	Springs	S-F.	Timken	Springs	118	32x4	SS	Wd	¾ Ell
Velie 39	1645	6	3½x5¼	29.4	303.1	4.45-1	Cont.	L.	H.	P.	Sp-Pr.	P.	Remy-2	6	Remy	⅞	Rayfld	V.	P.	Unit M.	4	Warner.	Sp.B	Springs	S-F.	Timken	Springs	124	33x4½	SS	Wd.	¾ Ell
Westcott S-18	2090	6	3½x5¼	29.4	303.1	4.45-1	Cont.	L.	H.	P.	Sp-Pr	P.	Delco-2	6	Delco	⅞	Rayfld	V.	D.	Unit M.	3	B-Lipe	Sp.B.	Springs	S-F.	Timken	Tor.T.	125	35x4½	SS	Wd.	Cant.
White .... 16 Valve Four	5000	4	4¼x5¾	28.9	326.3	. .	Own	T.	H.	P.	Pr.	G.	Lee-N-2	12	....	⅞	Own	V.	D.	Unit M.	4	Own	Sp.B.	Springs	S-F.	Own	Springs	137½ 124½	35x5	U.	Wd.	S-E
Willys-Knight 88-4	1625	4	4⅛x4½	27.2	240.5	4.30-1	Own	K	C.	T.	Sp-Pr	P.	A-Lite-2	6	Conn	⅞	Tiltsn	V.	C.	Unit X.	3	Own	Sp.B.	Tor.T.	F.	Own	Tor.T.	121	34x4½	SS	Wd.	Cant.
Willys-Knight 88-8	2100	8	3⅜x4	36.4	286.3	4.60-1	Own	K	C.	T.	Pr.	P.	A-Lite-2	6	Remy	⅞	Zenith	V.	C.	Unit X.	3	Own	Sp.B	Tor.T.	F.	Own	Tor.T	125	34x4½	SS	Wd.	Cant.
Willys 89	1450	6	3½x5¼	29.4	303.1	4.00-1	Cont.	L.	H.	P.	Sp-Pr	P.	A-Lite-2	6	Conn	⅞	Tiltsn	V.	C.	Unit X.	3	Own	Sp.B	Tor.T.	¾ F.	Own	Tor.T	120	33x4	SS	Opt.	Cant.
Winton 33	3150	6	3¾x5¼	33.7	347.9	4.45-1	Own	L.	C.	P.	Pr.	P.	Bijur-2	6	Bosch	⅞	Rayfld	V.	D.	Unit M.	4	Own	Sp.B.	Springs	F.	Own	Tor.R.	128	36x4½	QD	Wd.	¾ Ell
Winton 48	3850	6	4½x5½	48.6	524.8	4.08-1	Own	L.	C.	P.	Pr.	P.	Bijur-2	6	Bosch	⅞	Rayfld	V.	D.	Unit M.	4	Own	Sp.B.	Springs	F.	Own	Tor.R.	138	37x5	QD	Wd	¾ Ell
Woods 54	2950	4	2¾x4	12.1	95.0	8.25-1	Cont.	L.	H.	T.	Sp-Pr	P.	Own	60	A.Kent.	⅞	Stmbg.	G.	M.	Unit M.		Electric	Worm.	Springs	S-F	Own	Tor.A.	124	35x4½	QD	Wd	Cant.

*—*Optional*
1—*Single Unit*
2—*Two Unit*
A—*Air*
A-Ch—*Allis-Chalmers*
A.Kent—*Atwater Kent*
A-Lite—*Auto-Lite*
Amer—*American*
Amid—*Amidships*
B—*Bevel gear*
B—*Ball*
B&Ball—*Ball & Ball*
Beavr—*Beaver*
Brlng—*Berling*
B-Lipe—*Brown-Lipe*
B&Beck—*Borg & Beck*
Brp—*BRP*
C—*Chain*
C—*Cone*
Cant—*Cantilever*
Cir-Sp—*Circulat'g Splash*
Clumba—*Columbia*
Conn—*Connecticut*
Cont—*Continental*
C.U.—*Control Unit*
D—*Dead*
D—*Disk*
Ditwlr—*Ditwiler*
Dr&S—*Driggs Seabury*
DD—*Dry disk*
Drstn—*Durston*
Dtroit—*Detroit*
Dynto—*Dyneto*
Eismn—*Eisemann*
Ell—*Elliptic*
Empir—*Empire*
F—*Floating*
F—*Flywheel*
Fostr—*Foster*
G—*Gear oil pump*
G—*Gravity*
G,B&S—*Golden, Belknap & Swartz*
G&D—*Gray & Davis*
Gemr—*Gemmer*
G-Lees—*Grant-Lees*
Hartfd—*Hartford*
H—*Helical gear*
He-Shaw—*Hele-Shaw*
Heinz—*Heinze*
Her-Sp—*Herschell-Spillman*
Hrcls—*Hercules*
Hoosr—*Hoosier*
I—*Impeller*
Int.C—*Internal Chain*
J-M—*Johns-Manville*
Johnsn—*Johnson*
Kingstn—*Kingston*
Lee-N—*Leece-Neville*
L—*Long*
Lefevr—*Lefever*
Liget—*Liggett*
Longmr—*Longuemare*
Lycmg—*Lycoming*
M—*Magnetic*
MEvans—*Merchant & Evans*
Mech—*Mechanics*
Mas-Ph—*Massnick-Phipps*
Milwk—*Milwaukee*
N-Amer—*North American*
N-East—*North East*
Newcm—*Newcomb*
Non-Sp—*Non-splash*
Nortb—*Northway*
Opt—*Optional*
1—*Single-unit*
P—*Plain*
P—*Plate*
P—*Water Pump*
P—*Plunger oil pump*
P—*Pressure fuel feed*
Pr—*Pressure*
Plat—*Platform*
QD—*Quick Detachable*
QDR—*QD Reversible*
Rochtr—*Rochester*
R—*Roller*
R-My—*Robbins & Myers*
Rad. Rd—*Radius Rod*
Russl—*Russel*
Rayfld—*Rayfield*
Rutnbr—*Rutenber*
S E—*Semi-Elliptic*
S-Huff—*Simms-Huff*
S—*Spur Gear*
S-F—*Semi-Floating*
SS—*Straight side*
Schblr—*Schebler*
Slsby—*Salisbury*
Shldn—*Shelton*
Sp.B—*Spiral Bevel*
Sp—*Splash*
Sp-Pr—*Splash-pressure*
Splt—*Splitdorf*
Sp-Pr—*Splash-pressure*
Sterl—*Sterling*
Stewrt—*Stewart*
Stmbg—*Stromberg*
¾ Ell—*¾ Elliptic*
¾ F—*¾ Floating*
Timkn—*Timken*
T—*Thermo-Syphon*
Tiltsn—*Tillotson*
Timkn—*Timken*
Tor.A—*Torque Arm*
Tor T—*Torque Tube*
Trans—*Transverse*
2—*Two-unit*
UnitM—*Unit with engine*
UnitT—*Unit with torque tube*
Unit X—*Unit with axle*
V—*Vacuum*
Van-S—*Van Sicklen*
W-Lnr—*Ward Leonard*
W.W.—*Walker Weiss*
Wauk—*Waukesha*
Wagnr—*Wagner*
West—*Westinghouse*
WestM—*Weston Mott*
Widly—*Weidley*
Wis—*Wisconsin*
Wr—*Wire*
Wd—*Wood*
Zen Sp—*Zenith Special*

RT NO. 232—Specifications of Leading 1918 Cars—continued. See corrections, pages 544, 546.
and 234 omitted (error in numbering). See index for 1919 Specifications.

Orphan Cars.

Parts for Cars No Longer Manufactured—Where to Obtain the Parts.

bott	Consolidated Car Co., Detroit Puritan Machine Co., Detroit Jos. C. Gorey & Co., New York Abbott-Detroit Parts Corp., New York
me	Puritan Mach. Co., Detroit
rocar	Auto Parts Co., Chicago Puritan Machine Co., Detroit
co	International Motor Co., New York Puritan Mach. Co., Detroit Jos. C. Gorey & Co., New York American Locomotive Co., Providence, R. I. Alco Service Co., Philadelphia Rand & Chandler, Los Angeles, Cal.
lden-Sampson	Standard Motor Parts Co., New Castle, Ind.
llen-Kingston	New Departure Co., Bristol, Conn.
lis-Chalmers	Puritan Machine Co., Detroit
lpena	Puritan Machine Co., Detroit
merican	Levens Motor Co., Philadelphia, Pa American Motor Parts Co., Indianapolis V. A. Longaker Co., Indianapolis Jos. C. Gorey & Co., New York Puritan Mach. Co., Detroit Burt Motor Car Co., Los Angeles, Cal.
American Mors	St. Louis Car Co., St. Louis
American Truck	Auto Parts Co., Chicago
Amplex	Gillette Motors Co., Mishawaka, Ind.
Anchor	Anchor Buggy Co., Cincinnati
Anhut	Puritan Machine Co., Detroit Auto Parts Co., Chicago
Ardsley	Ardsley Motor Car Co., Yonkers, N. Y.
Argo	Puritan Mach. Co., Detroit
Atlantic	Puritan Machine Co., Detroit
Atlas	Auto Parts & Repair Co., Springfield, Mass. Puritan Machine Co., Detroit Jos. C. Gorey, New York City
Autocar	Autocar Co., Ardmore, Pa.
B	
Babcock	Babcock Mfrs. Supply Co., Watertown, N. Y. Puritan Machine Co., Detroit
Badger	Schultz & Harder, Columbus, Wis. Puritan Machine Co., Detroit
Barnes	Auto Parts Mfg. Co., Detroit Puritan Machine Co., Detroit
Benham	Puritan Mach. Co., Detroit
Bergdoll	Louis J. Bergdoll Co., Philadelphia Levene Motor Co., Philadelphia Jos. C. Gorey, New York City
Berkshire	E. B. Belcher, Cambridge, Mass. Berkshire Motor Co., Pittsfield, Mass. Puritan Machine Co., Detroit
Berliet	American Locomotive Co., Providence, R. I.
Bessemer	Robt. M. Cutting Co., Chicago
Black Crow	Black Mfg. Co., Chicago Crow Motor Car Co., Elkhart, Ind.
Blomstrom	Auto Parts Co., Detroit Puritan Machine Co., Detroit
Borland	Puritan Machine Co., Detroit
Briggs-Detroiter	Puritan Machine Co., Detroit
Bristell	Puritan Machine Co., Detroit
Brownikar	Hinsdale Electrical S. Co., Hinsdale, Ill
Broc Electric	Puritan Machine Co., Detroit
Brodesser	Puritan Machine Co., Detroit
Brush	Standard Motor Parts Co., Newcastle, Ind. Puritan Machine Co., Detroit Davidson Repairshop, 227 West 64th St., New York, N. Y.
Buffalo Electric	Puritan Machine Co., Detroit
C	
California	California Auto Co., Los Angeles, Cal. Puritan Machine Co., Detroit
Cameron	Cameron Mfg. Co., New Haven, Conn.
Carhartt	Auto Parts Co., Chicago Jos. C. Gorey & Co., New York Puritan Machine Co., Detroit
Carnation	Carnation Motor Car Co., Detroit Auto Parts Co., Chicago Puritan Machine Co., Detroit K. C. Auto Parts Co., 1827 McGee St., Kansas City, Mo
Cartercar	Puritan Machine Co., Detroit
Carthage	Puritan Mach. Co., Detroit
Cavac	Puritan Machine Co., Detroit
Century	Puritan Mch. Co.; 422 Lafayette Blvd., Detroit
Chadwick	Chadwick Eng. Works, Pottstown, Pa.
Chief	Auto Parts Mfg. Co., Detroit Chief Motor Co., Detroit
Cino	Haberer & Co., Cincinnati
Cinco	Puritan Mach. Co., Detroit
Clark	Clark Motor Car Co., Shelbyville, Ind. Meteor Motor Car Co., Piqua, Ohio Clark Auto Co., Atlanta, Ga. Puritan Machine Co., Detroit American Motors Parts Co., Indianapolis
Clark-Carter	Cutting Motor Car Co., Jackson, Mich. L. C. Erbes, Waterloo, Iowa Puritan Machine Co., Detroit Robt. M. Cutting Co., 2635 S. Wabash Ave., Chicago
Cleveland	Western Motor Car Co., Cleveland, Ohio Garford Motor Truck Co., Lima, Ohio
Coates-Goshen	Coates-Goshen Auto Co., Goshen, N. Y Miller Car Co., Goshen, N. Y.
Colby	A. O. Smith, Milwaukee, Wis.
Colburn	Colburn Automobile Co., Denver, Col Erickson & Stalnaker, Denver, Col Puritan Mach. Co., Detroit
Colley	Puritan Machine Co., Detroit
Columbia	Columbia Auto Repair Co., Hartford, Conn Standard Motor Parts Co., Newcastle, Ind
Columbus Electric	New Columbus Buggy Co., Columbus, Ohio
Connersville	Puritan Machine Co., Detroit
Continental	Puritan Mach. Co., Detroit
Corbin	Corbin Motor Vehicle Co., New Britain, Conn.
Corbitt	Puritan Machine Co., Detroit
Correja	J. C. Gorey & Co., New York
Courier	Standard Motor Parts Co., Newcastle, Ind. Puritan Machine Co., Detroit
Courier-Clermont	Standard Motor Parts Co., Newcastle, Ind.
Craig-Toledo	A. W. Colter, Toledo Puritan Machine Co., Detroit
Crescent	Northway Auto Parts & Sales Co., Cincinnati Puritan Machine Co., Detroit
Cricket	Puritan Machine Co., Detroit
Crow	Black Mfg. Co., Chicago Crow M. C. Co., Elkhart, Ind. Puritan Mach. Co., Detroit
Croxton	Auto Parts Co., Chicago Puritan Machine Co., Detroit
Croxton-Keeton	K. C. Auto Parts Co., 1827 McGee St., Kansas City, Mo.
Cutting	Puritan Machine Co., Detroit Harris Bros. Co., Chicago S. C. Erbes, St. Paul, Minn.
D	
Dart	Puritan Machine Co., Detroit
Dayton	Puritan Machine Co., Detroit
Deal	Auto Parts Co., Chicago
Dearborne-Detroit	Hawn Motor Car Co.
De Luxe	Puritan Machine Co., Detroit
De Mot	Puritan Machine Co., Detroit
De Tamble	American Motors Parts Co., Indianapolis Puritan Machine Co., Detroit De Tamble Motors Co., Anderson, Ind.
Dragon	Philadelphia Mch. Wks., Philadelphia
Duer	Chicago Coach & Carriage Co., Chicago
Durocar	Puritan Machine Co., Detroit
E	
Eclipse	Kruegar Motor Car Co., Milwaukee Frank Toepfer's Sons, Milwaukee
Edwards	Edwards Motor Car Co., Long Island City, N. Y. Puritan Machine Co., Detroit
Electric Vehicle	Maxwell Briscoe Motor Co., L. I. City, N. Y.
Elk	Puritan Machine Co., Detroit
Elmore	Auto Parts Co., Chicago Jos. C. Gorey & Co., New York Puritan Machine Co., Detroit Standard Motor Parts Co., New Castle, Ind.
Evertt	Holt-Chandler, Long Island City, N. Y.
Everitt	Maxwell Motor Sales, Newcastle, Ind. Jos. C. Gorey & Co., New York Puritan Machine Co., Detroit
Ewing	Jos. C. Gorey, New York Puritan Mach. Co., Detroit L. E. Ewing, Leader Bldg., Cleveland, O.
F	
F. A. L.	Puritan Machine Co., Detroit Auto Parts Co., Chicago K. C. Motor Parts Co., 1827 McGee St., Kansas City, Mo.
Findley	L. E. Ewing, Cleveland
Firestone Columbus	Puritan Machine Co., Detroit New Columbus Buggy Co., Columbus, Ohio
Flanders	Puritan Machine Co., Detroit Studebaker Corp., Detroit
Fuller	Jackson Automobile Co., Jackson, Mich.
G	
Gaeth	Gaeth Motor Car Co., Cleveland
Garford	Elyria Belting & Machinery Co., Elyria, Ohio Garford Motor Truck Co., Lima, Ohio Puritan Mach. Co., Detroit
G. J. G.	Puritan Machine Co., Detroit
Glide	Jos. C. Gorey & Co., New York
Grabowsky	Puritan Machine Co., Detroit Jos. C. Gorey, New York City
Gramm	Garford Motor Truck Co., Lima, Ohio Puritan Machine Co., Detroit
Gleason	Bauer Mch. Wks. Co., Kansas City, Mo.
Great Smith	Bauer Mch. Wks. Co., Kansas City, Mo. Smith Automobile Co., Topeka, Kan.
Great Western	Great Western Auto Co., Peru, Ind.
Grout	A. F. Kirkpatrick, Orange, Mass. Puritan Mach. Co., Detroit
H	
Halladay	A. O. Barley, Streator, Ill. A. O. Smith Co., Milwaukee W. J. Burt Motor Car Co., Los Angeles
Hart-Kraft	Quincy Engine Co., Chambersburg, Pa. Petrie & Morganthall, Greencastle, Pa.
Havers	Puritan Machine Co., Detroit Jos. C. Gorey, New York
Henderson	Henderson Motor Car Co., Detroit Auto Parts Co., Chicago Puritan Machine Co., Detroit
Henry	A. O. Smith Co., Milwaukee Jos. C. Gorey, New York Puritan Machine Co., Detroit Muskegon Auto Co., Muskegon, Mich.
Herreshoff	American Motor Parts Co., Indianapolis Puritan Machine Co., Detroit Levene Motor Co., Philadelphia Jos. C. Gorey, New York
Hewitt	International Motor Co., New York
Holsman	Mercury Mfg. Co., Chicago
Houpt	New Departure Mfg. Co., Bristol, Conn.

—from Motor World.

Additions.

Argo Electric, Briggs-Detroiter, Elco, Little Four, Yale Eight, Partin-Palmer. Parts for sale by Puritan Machine Co., Detroit, Mich.

I	
Imperial	Imperial Automobile Co., Detroit
Indiana	Puritan Machine Co., Detroit
J	
Jenkins	Puritan Machine Co., Detroit
Jewell	Croxton Motor Car Co., Washington, Pa.
Johnson	Johnson Service Co., Milwaukee
K	
Keeton	Keeton Motor Car Co., Detroit Puritan Machine Co., Detroit Car-Nation Motor Car Co., Detroit
Kelly-Springfield	Puritan Machine Co., Detroit
Kelsey	Auto Parts & Repair Co., Boston Kelsey Motor Co., Hartford, Conn.
Kline	Puritan Machine Co., Detroit
Knox	Alco Service Co., Philadelphia, Pa.
Komet	Elkhart Motor Car Co., Elkhart, Ind. Keith Brothers, Elkhart, Ind.
Krall	Puritan Machine Co., Detroit
Krit	Puritan Machine Co., Detroit Krit Motor Car Co., Detroit Auto Parts Co., Chicago Motor Corp., Philadelphia, Pa.
L	
Lansden	Lansden Co., Inc., Brooklyn, N. Y.
Lewis	American Motor Parts Co., Indianapolis
Lexon	Puritan Mach. Co., Detroit
Liberty	Belmont Auto Mfg. Co., New Haven, Conn.
Lion	American Motors Parts Co., Indianapolis Auto Parts Co., Chicago Puritan Machine Co., Detroit K. C. Auto Parts Co., 1827 McGee St., Kansas City, Mo. Lion Motor Parts Co., Philadelphia, Pa.
Little Six	Puritan Machine Co., Detroit
Logan	Garford Motor Truck Co., Lima, Ohio Gramm Motor Truck Co., Lima, Ohio
Lozier	Puritan Mach. Co., Detroit Jos. C. Gorey & Co., New York Phila. Mach. Works, Philadelphia, Pa.
L. P. C.	American Motors Parts Co., Indianapolis Auto Parts Co., Chicago
M	
McIntyre	Puritan Mach. Co., Detroit
Marathon	Marathon Service Co., Nashville, Tenn Puritan Machine Co., Detroit
Marion	Puritan Mach. Co., Detroit Auto Parts Co., Chicago Jos. C. Gorey & Co., New York American Motors Parts Co., Indianapolis Marion Auto Service Co., New York City K. C. Auto Parts Co., 1827 McGee St., Kansas City, Mo
Marron	Puritan Mach. Co., Detroit
Marquette	Puritan Machine Co., Detroit
Marvel	Puritan Machine Co., Detroit
Mason	Mason Motor Car Co., Detroit Puritan Mach. Co., Detroit
Mather	Puritan Machine Co., Detroit
Matheson	Matheson Auto Co., Wilkes-Barre, Pa
Maxwell	Standard Motor Parts Co., Newcastle, Ind Puritan Machine Co., Detroit
Maytag-Mason	Mason Motor Car Co., Detroit Puritan Machine Co., Detroit
Merchant	Puritan Machine Co., Detroit
Meteor	Meteor Motor Car Co., Piqua, Ohio
Michigan	Michigan Motor Car Co., Detroit Puritan Machine Co., Detroit Philadelphia Mach. Wks., Philadelphia Dauch Mfg. Co., Sandusky, Ohio Jos. C. Gorey, 354 W. 50th St., New York City K. C. Auto Parts Co., 1827 McGee St., Kansas City, Mo
Middleby	Puritan Machine Co., Detroit H. Goldberg, 1420 S. 8th St., Philadelphia A. J. Levengood, 153 N. 4th St., Reading, Pa
Midland	Levene Motor Co., Philadelphia Puritan Machine Co., Detroit Auto Parts Co., Chicago K. C. Auto Parts Co., 1827 McGee St., Kansas City, Mo Midland Motor Co., 2200 Diamond St., Philadelphia, Pa.
Mier	Mier Carriage & Buggy Co., Ligonier, Ind.
Miller	Puritan Mach. Co., Detroit
Milwaukee	L. C. Erbes, Waterloo, Iowa Harris Bros. Co., Chicago
Monarch	Puritan Mach. Co., Detroit
Mora	Jos. C. Gorey, New York Philadelphia Mch. Wks., Philadelphia
Moyer	Puritan Machine Co., Detroit
N	
Nance	Jos. C. Gorey, New York
Northern	Puritan Machine Co., Detroit
North Western	Puritan Machine Co., Detroit
Nyberg	Puritan Machine Co., Detroit Levene Motor Co., Philadelphia V. A. Longaker, Indianapolis
O	
Ohio	Northway Auto Parts & Sales Co., Cincinnati A. O. Smith Co., Milwaukee Puritan Machine Co., Detroit
Oliver	Oliver Motor Truck Co., Detroit Puritan Machine Co., Detroit
Omaha	A. O. Smith Co., Milwaukee Puritan Machine Co., Detroit
Orient	Metz Co., Waltham, Mass.
Orson	Drenco Machine Co., Broadway & 50th St., New York City
Otto-mobile	Holly Motor Co., Mt. Holly, N. J.
Overholt	A. O. Smith Co., Milwaukee
Owen	Puritan Machine Co., Detroit
P	
Packers	Puritan Machine Co., Detroit
Palmer-Singer	Singer Motor Co., Lond Island City, N. Y. Puritan Machine Co., Detroit Jos. C. Gorey & Co., New York A. O. Smith Co., Milwaukee Drenco Mach. Co., Bwy. & 50th St., New York City
Parry	Motor Car Mfg. Co., Indianapolis Pathfinder Co., Indianapolis, Ind.
Peabody	Puritan Machine Co., Detroit
Penn	Puritan Machine Co., Detroit Buda Co., Harvey, Ill Levene Motor Co., Philadelphia
Pennsylvania	Puritan Mach. Co., Detroit Central Auto Supply Co., Philadelphia Jos. C. Gorey & Co., New York Dougherty, 1845 N. 15th St., Philadelphia
Peru	Puritan Mach. Co., Detroit
Petrel	Filer & Stowell Co., Milwaukee
Pierce-Racine	Puritan Machine Co., Detroit Pierce Motor Co., Racine, Wis
Pioneer	Pioneer Car Mfg. Co., Oklahoma City, Okla
Pittsburgh	Chester Engineering Co., Chester, Pa
Pope-Hartford	Hartford Motor Car Co., Hartford, Conn Walker & Barkman Mfg. Co., Hartford, Conn Puritan Machine Co., Detroit Boulevard Motor Co., Cambridge, Mass J. Rosenfeld, 521 6th St., South, Boston
Pope-Toledo	Auto Salvage Parts Co., Chicago
Pope-Tribune	Pope-Hartford Mfg. Co., Hartford, Conn
Poss	Puritan Mach. Co., Detroit
Pratt-Elkhart	Elkhart Carriage & Motor Car Co., Elkhart, Ind
Pungs-Finch	Pungs-Finch Auto & Gas Engine Co., Detroit
Q	
Queen	Puritan Machine Co., Detroit
R	
Randolph	Randolph Motor Truck Co., Flint, Mich De Kalb Wagon Co., De Kalb, Ill
Rainier	Puritan Machine Co., Detroit Garford Motor Truck Co., Lima, Ohio
Rapid	Puritan Machine Co., Detroit
Rayfield	Holmes Garage, Danville, Ill
R. C. H.	R. C. H. Corp, Detroit Jos. C. Gorey, New York W. J. Burt Motor Car Co., Los Angeles, Cal Puritan Machine Co., Detroit
Reading	H. Goldberg, 1420 S. 8th St., Reading, Pa
Reed	Puritan Mach. Co., Detroit
Reliable-Dayton	Puritan Machine Co., Detroit
Reliance	Puritan Mach. Co., Detroit
Republic	Republic Motor Car Co., Youngstown, Ohio
Ricketts	Ricketts Auto Works, Detroit
Rider-Lewis	Levene Motor Co., Philadelphia Puritan Machine Co., Detroit V. A. Longaker, Indianapolis Auto Parts Mfg. Co., Detroit
Royal Tourist	Puritan Mach. Co., Detroit
S	
Sampson	Standard Motor Parts Co., Newcastle, Ind Puritan Machine Co., Detroit
Sandusky	Dauch Mfg. Co., Sandusky, Ohio
Schacht	General Auto Repairs Co., Cincinnati Puritan Machine Co., Detroit
Selden	Jos. C. Gorey & Co., New York Puritan Machine Co., Detroit
S. G. V.	Drenco Mach. Co., Broadway & 50th St., New York City N. J. Machinery Co., Newark, N. J.
Sibley	Sibley Motor Car Co., Detroit
Sommer	Sommer Motor Co., Detroit
Southern	Southern Auto & Equipment Co., Atlanta, Ga Puritan Machine Co., Detroit
Spaulding	Puritan Machine Co., Detroit
Speedwell	Puritan Mach. Co., Detroit Jos. C. Gorey & Co., New York Green Engineering Co., Dayton, Ohio
Springfield	R. Hass Elec. & Mfg. Co., Springfield, Ill
Standard Six	St. Louis Car Co., St. Louis, Mo Puritan Machine Co., Detroit
Star	Mier Carriage & Buggy Co., Ligonier, Ind
Staver	Puritan Machine Co., Detroit
Sterling	Keith Brothers, Elkhart, Ind
Stevens-Duryea	Walk Hill Garage, 726 Walk Hill St., Mattapan, Mass
Stoddard-Dayton	Standard Motor Parts Co., Newcastle, Ind Puritan Machine Co., Detroit Dayton Auto Repair Co., New York City
Suburban	Puritan Machine Co., Detroit
Sultan	Jos. C. Gorey, New York City
T	
Thomas	E. R. Thomas Motor Car Co., Buffalo, N. Y. Puritan Machine Co., Detroit W. H. Jahns, 908 W. Pico St., Los Angeles, Cal J. Rosenfeld, 521 6th St., South, Boston
Tincher	Chicago Coach & Carriage Co., Chicago
Tourine	Jos. C. Gorey, New York
Tourist	W. J. Burt Motor Car Co., Los Angeles, Cal
Traveler	Traveler Automobile Co., Evansville, Ind
Twombly	Driggs-Seabury Ordnance Co., Sharon, Pa
V	
Van	L. C. Erbes, Waterloo, Iowa
Van Dyke	Puritan Mach. Co., Detroit
Victor-Thomas-Detroit	Puritan Machine Co., Detroit
W	
Wagenhalls	Riverside Machinery Depot, Detroit
Wahl	Harris Bros. Co., Chicago Barley Mfg. Co., Streator, Ill Puritan Machine Co., Detroit
Waltham-Orient	Metz Co., Waltham, Mass
Warren	Jos. C. Gorey & Co., New York Puritan Machine Co., Detroit
Washington	Puritan Machine Co., Detroit
Waverley Electric	V. A. Longaker Co., Indianapolis
Wayne	Auto Parts Mfg. Co., Detroit Puritan Machine Co., Detroit
Welch-Detroit	Puritan Machine Co., Detroit
Welch-Marquette	Oldsmobile Co., Chicago, Ill
Welch-Pontiac	Puritan Machine Co., Detroit
Whiting	Chevrolet Motor Co. of Mich., W. Kearsley St. Flint, Mich. Puritan Machine Co., Detroit
Woodwerth	Puritan Machine Co., Detroit
Y	
Yale	Consolidated Mfg. Co., Toledo, Ohio
Z	
Zip	H. A. Huebotter, Davenport, Iowa

To find addresses of Ignition, Magneto, Electric System Manufacturers, also Auto Trade Publications etc.—look under "Addresses" in the index.

INSTRUCTION No. 41.

**TIRES: Pneumatic. Treads. Rims: attaching and detaching. Proper Tire Inflation. Oversize Tires. Finding Wheel Load. Tire Pointers. Puncture Proof Tires. Air Pumps and Compressors. Various Uses of Compressed Air in a Garage. Anti-Skid-Chains. Solid Tires. Truck Tires for Heavy Duty.

Tires are used on automobiles to overcome the vibration. If the wheels of an automobile were not properly tired, the machine would soon rack itself to pieces. The great weight and speed of the automobile and its delicate construction, require additional protection besides that of the springs alone.

There are two types of tires, the solid and the pneumatic. The **solid tire is used** to a great extent on electric vehicles and trucks, because they are usually slow speed vehicles. If solid tires were used on high speed cars the vibration would be so great the car would soon rack itself to pieces.

The Pneumatic Tire.

The pneumatic tire is the type used on all pleasure cars. With pneumatic tires, the car is suspended in air, which is the most elastic of substances.

There are two methods of retaining the air, the first and now obsolete method, was a single tube tire, made air tight and did not use an inner tube.

There are two forms of pneumatic tires; the single and the double tube. The single tube tire was merely an outer casing made air tight and was fitted with an air valve. This type was used extensively during the early days of motoring, but inasmuch as it is now obsolete, we will confine our instruction mainly to the modern type.

The modern automobile pneumatic tire consists of two chief parts, the "inner tube," which holds the air, and the "shoe or casing," which retains the inner tube, and protects it from wear. (fig. 2, page 550.)

A steel rim is placed around the felloe of the wheel, and shaped to fit the tire, its exact shape depending on the design of the tire. The clincher and straight side rim are the styles universally used.

Double tube tires have projections on the side called beads, which fit under grooves or into channels in the side of the rim, the pressure of the air in the inner tube holding them in place. See figs. 8, 8A and 9, page 552.

***Bolts, or lugs,** also sometimes called stay bolts or security bolts (fig. 2) pass through the felloe and rim, their large rubber or canvas-covered heads holding the extreme inner edges of the shoe against the rim.

Tread, is the part of an outer shoe or casing, which is the part that comes in contact with the road. **Bead,** is the projection at the edges that fit into the rim.

Outer cases, also called the outer shoe are divided into two classes; the "fabric" type and the "cord" type as explained on pages 565 and 559. **The strength of the tire lies in this fabric or cord carcass, the cushion and protection for the carcass of the tire is in the rubber.** Sea Island cotton which is very strong, is used for the carcass of the fabric tire and cords are used for the carcass of the cord tire.

Inner Tube and Valve.

Inner tubes used on automobile pneumatic tires are of the endless type. The only opening into the tube is the valve, through which the air is forced, fig. 6, page 550. As tube becomes inflated by air pumped into it, the bead of tire is forced outward and tightly clinches to the rim channel and can only be dislodged by deflating tube.

†**The inner tube valve-stem** is the part shown in fig. 6, page 550. It is the part to which the inner tube is connected as shown in fig. 5. (T) is the inner tube. The base, (G) of the valve stem is passed through a heavy, tough piece of rubber, called the "valve-stem-seat" which is vulcanized to the tube as shown in fig. 6, page 572. By stretching the opening in this valve stem seat, the base (G) is placed inside of tube and firmly locked by clamp nut (ST), figs. 5 and 6, page 550.

The inner-valve A, fig. 6A, also called the "valve plunger," is an automatic air check valve for retaining the air in the tube. It is screwed into valve stem opening, usually by the notched end of (B) the valve cap (see fig. 2, page 568). V—is the threaded part which screws into valve stem. W, is metal with rubber packing (D) around it, which makes an air-tight joint with walls of valve-stem. Y is cap holding spring (S) in place, and on upper part is a rubber washer which is the "valve-seat" which is between bottom of (W) and upper part of (Y). This is the seat, or point where air pressure in tube is retained because the lower part of (W) is in contact with rubber washer seat on top of Y, which is held together by tension of spring. This seat is shown open in illustration. Pin (U) is firmly attached to Y but works freely through enlarged holes in V and W, which hole also serves as the air passage to or from valve seat. The spring holds the valve to its seat but can be depressed at (U) or air from air pump will be sufficient to force valve from its seat.

To inflate tube, unscrew valve cap (B) and screw in its place the hose coupling from air line. Inside of this hose coupling is a projection which presses the pin (U) down against tension of spring (S) which separates the seat on upper part of Y from lower part of W—the air then passes in through enlarged hole in V and W and out bottom of W at seat, which is now open. When air-line coupling is removed pin U raises and brings upper part of Y and bottom part of W to a firm seat, and pressure of air in tube also assists in forcing spring S against Y and tightening the seat.

---

*Lugs are now seldom used owing to the great number of quick detachable clincher rims now in use, and it has been proven by experience, that they are not needed.

**See Specifications of Leading Cars, pages 543 to 546, for make and size tires used on leading cars.

†Valve stem is passed through hole in felloe of wheel—see page 558, fig. 2A. Stem is held in place by lock nut (N) and washer (M), fig. 6, page 550. See page 571 for purpose of the spreader.

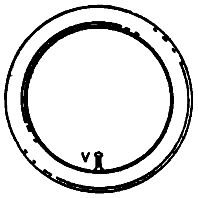


Fig. 1—The old style and original pneumatic tire was a "single tube tire." The casing itself held the air and did not contain an inner tube.

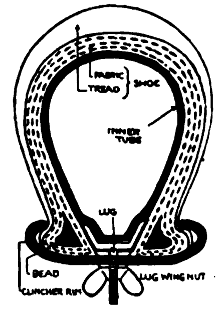


Fig. 2—The old style double tube clincher bead tire on a one piece clincher rim. Note the lug formerly used to hold tire on the rim. Pneumatic tires were called "double tube" tires in the early days to distinguish them from the single tube tire, fig. 1.

The clincher tire can be applied to a quick detachable clincher rim.

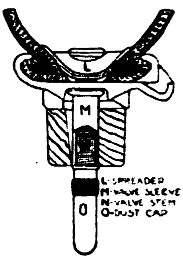


Fig. 3 — A quick detachable demountable "clincher" rim.

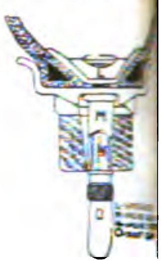
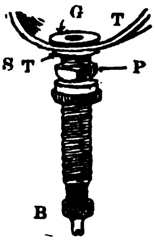


Fig. 4—A detachable mountabl straight sid

Fig. 5 — All pneumatic tires now contain inner tubes. Note method of clamping the air valve to inner tube. Inner tubes are endless and seamless.

T, tube; G, base; ST, clamp nut; P, lock-nut.



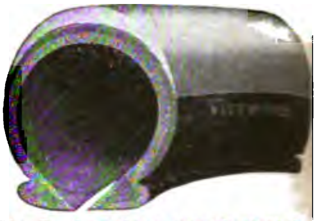


Fig. 7—A modern smooth tread ti- made in quick detachable clin- regular clincher and straight side typ of bead. Above illustrates the smo tread quick detachable clincher b

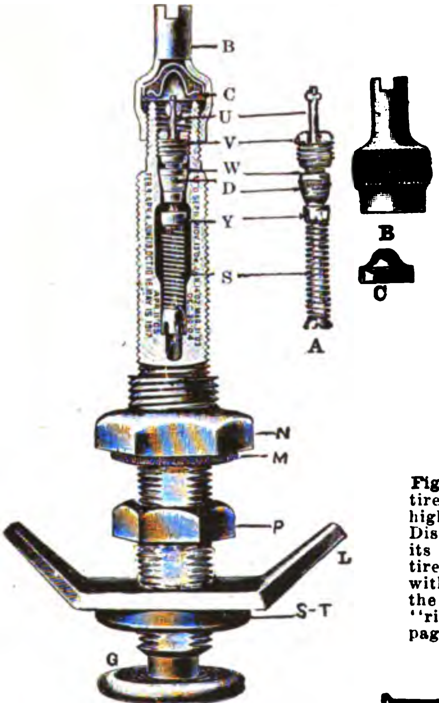


Fig. 6—Schrader No. 777 inner tube valve; full size for 3 in. tubes and under. No. 725 for 3½ in. and over is larger.

- A—Inner valve.
- B—Valve cap.
- C—Rubber disk (for cap B).
- D—rubber packing.
- N—Locking nut (for dust cap).
- M—Leather washer.
- G—Valve stem base, goes inside of tube.
- P—Lock nut (for valve stem).
- S-T—Clamp disk.
- L—Valve spreader.

See pages 549, 551 for inner valve principle.

Fig. 8A—The cord tire; a popular but high priced tire. Distinguishable by its tread. The cord tire is also made with non-skid tread. the above is the "ribbed" tread. See page 559.

Fig. 8—A modern non-skid tread tire—made in quick detachable clincher, regular clincher and straight side type of bead—

Fig. 8A — The Cord tire, principle of which is explained on page 559, is distinguishable by its tread, which is a characteristic standard used by many of the tire concerns who make Cord type of tires.

Fig. 8—Non-skid tread.

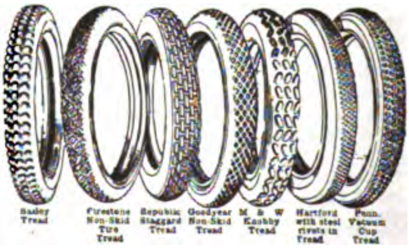


Fig. 9—Types of non-skid tires.

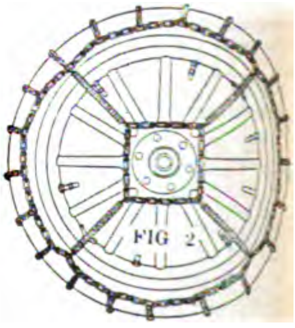


Fig. 10—Non-skid chains. Suitable only for snow, ice and mud. The chains are placed over the tires. See chart 236-I for grip or chain for solid tires. The chain is a sure preventive of slipping.

HART NO. 235—Tires—Original and Modern Types. Inner Tube Valve Construction.
harts 233 and 234 omitted by error in numbering.

To deflate tube, valve cap B is removed, turned upside down (per fig. 2, page 558) and pin U (fig. 6A, page 550) is pressed down by it, which opens inner-valve seat. Or, the valve cap B can be used to unscrew inner valve at V and removed entirely, which is the proper thing to do when removing a punctured tube or rolling it up, per fig. 7, page 568.

Slow Air Leaks.

Slow air leaks from tube are sometimes traced to this "inner-valve" A, leaking. †**To test for inner-valve leak,** inflate tube and test, per fig. 3, page 568. If leaky, try cleaning and screwing down tight, if this does not remedy leak, then put in a new "inner-valve." A slow leak may also be due to valve-stem base (G) being loose—or inner tube rubber being porous, due to age which in time hardens, becomes porous and leaks slowly. **To test for valve stem or slow leak or puncture;** see fig. 4, page 568. **The average life of a tube** is from twelve to eighteen months, maybe two years—but once it begins to harden—it is advisable to replace with new tubes.

The purpose of the spreader (L), fig. 6, page 550 is explained on page 571.

Treads of Tires.

The treads of tires or outer casings are divided into three types; the smooth tread, as shown in fig. 7, and the **non-skid tread** (fig. 8) and the **ribbed tread,** fig. 8A, page 550. There are several different makes of non-skid treads, (as shown in fig. 9) but the principle or purpose of all are to prevent skidding. The original non-skid tire was the Bailey tread. The Firestone non-skid tread was the second tire of this type introduced.

The number of accidents which have occurred on account of skidding on slippery pavements, has shown the need for some method of prevention.

****The original method was by the use of tire chains** (fig. 10), which, so far as the prevention of skidding was concerned, fulfilled their purpose. But the use of chains was found to be detrimental to tires when introduced between the blown-up tire and hard pavement, and in addition were a great source of trouble and hard riding, aside from the noise.

The non-skid tread was introduced to overcome this difficulty, but while they prevent skidding to a great extent, it still seems as though the chain is the best preventive of skidding after all. The extra wear and gripping surface obtained with the non-skid tread is well worth the difference in price, and ought to at least be placed on the rear wheels.

The modern tire equipment consists of smooth or ribbed tires for the front wheels and non-skid tread tires for the rear wheels, with rims of the quick detachable demountable type.

Leather cover protection for tires: In fig. 5, page 559, we illustrate a tire protector called the Woodworth Leather Tread. This cover is made of leather with steel rivets which pass through the tread. The covers are made to fit over the tire. They protect the tire from wear and from punctures, cuts and bruises, or other outside injuries, but are not suitable for high speed cars.

‡Rims.

There are two classes of rims—the clincher and the straight side.

The clincher type is divided into three types, the **plain one-piece clincher rim,** the **quick detachable type,** and the **quick detachable demountable type.**

The plain clincher type of rim is permanently fastened to the felloe of the wheel and in order to put a tire on this rim, it is necessary to place the inside bead of tire in the clinch, then force the outer bead under the outer clinch, inner tube having been inserted first. (See chart 236-D.)

The quick detachable rim is a type of rim which is also permanently fastened to the felloe of the wheel, but the outer "clinch" of the rim is removable. (See fig. 12, chart 236-C, and fig. 3, chart 236-B.) There are several different makes of quick detachable rims, but the purpose of all are to save time in attaching and detaching the tire.

It will be observed by referring to chart 236, the clincher tire or the **straight side** tire can be placed on this quick detachable type of rim by reversing the beads of the rim. (see figs. 2 and 3). This type of quick detachable rim is called the **reversible type of Q. D. rim.**

Quick detachable demountable rims permit the damaged tire to be removed with rim and another (which is usually carried on the rear or side of the car fully inflated) placed in its place. (See figs. 4 and 5, chart 236.) This type can be of the reversible ring or of the split type, to take either a clincher or straight side tire. In the split rim type, the rim is removed from the tire instead of the tire being removed from the rim. (see figs. 1 to 10, chart 236-C).

***A spare emergency tire and rim** is illustrated in fig. 7, chart 236. With this type (seldom used) the tire is carried along the side of the car fully inflated and on a special rim, but instead of this tire and rim being slipped over the rim in place of tire damaged, it is attached to the wheel alongside of the damaged tire, and is used temporarily until the car reaches home and damage tire is repaired.

****For heavy weather and snow time there is nothing equal to a good set of chains;** one on each wheel. If only two are used they should be on the **rear** wheels. If only one, it should be on the left rear, to avoid being damaged against the curb. Fasten them tightly, but not so tightly that they cannot creep. If they are held rigidly in one place they wear into the tread and ruin it (see pages 550, 559).

*The objection to this type is due to the fact that the wheels do not track properly. On country roads with ruts this becomes serious. †Sometimes the inner-valve leaks, due to the valve cap (B) being screwed down so tight the rubber disc (C) spreads and forces pin (U) down.

‡**The straight side rim is the popular rim.**

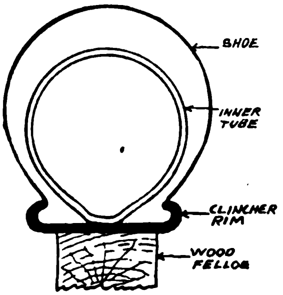


Fig. 1—Clincher tire on a one piece clincher rim.

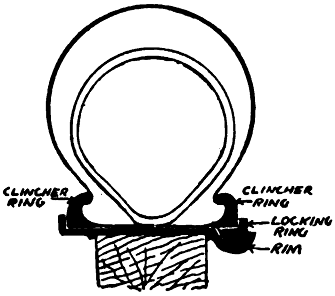


Fig. 2—Clincher tire on a quick detachable rim.

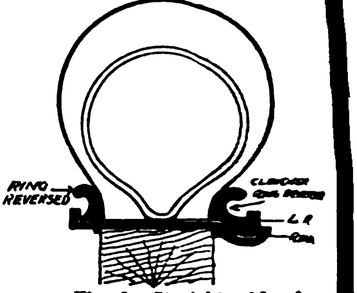


Fig. 3—Straight side tire on a quick detachable rim when the clincher part of rim is reversible.

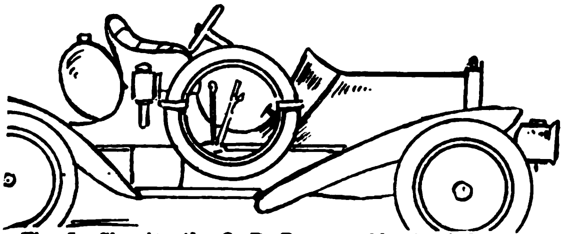


Fig. 5—Showing the Q. D. Demountable tire inflated on the demountable rim carried on the side of the car or the rear, ready to put in the place of a damaged tire. Note, this tire is inflated

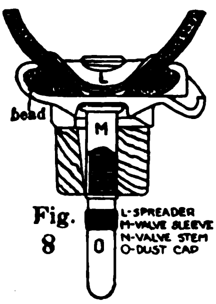


Fig. 8

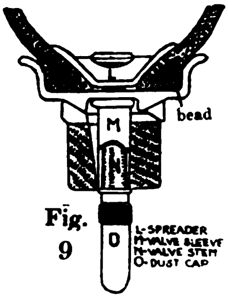


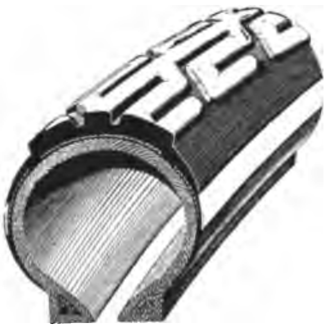
Fig. 9

Types of Tire Beads.

Fig. 8—A clincher hard, non-stretchable bead tire on a quick detachable, demountable rim.

Fig. 8A—A clincher flexible bead tire is practically the same tire except bead is flexible and is used on the "one-piece" clincher rim fig. 1. (Fg. 8A not illustrated.)

Fig. 9—A straight side bead tire on a quick detachable, demountable rim.



A straight side bead tire with a non-skid tread. Can be either the "fabric" or "cord" type of carcass, as explained on page 565.

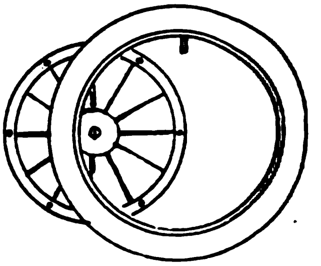


Fig. 4—A clincher tire on a demountable quick detachable clincher rim. Note the inner part of rim is permanently attached to felloe of wheel. This tire is usually carried on rear of car inflated on the outer part of rim. The damaged tire is removed and the inflated tire and rim is slipped over the wheel rim. The straight side or clincher tire can be demountable.

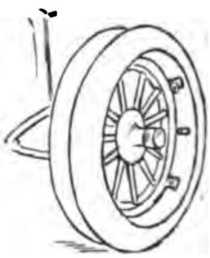


Fig. 7 — Spare emergency tire and rim is a type of tire usually carried inflated on a special rim which can be bolted or clamped to the side of the damaged tire. The damaged tire is not removed until destination is reached This principle is seldom used.

Fig. 8—Quick detachable clincher cases have non-stretchable beads and can only be used on quick detachable clincher rims and the split type clincher rims. This style of tire should always be equipped with flaps.

Fig. 8A—Regular clincher cases have stretchable or flexible beads and are designed for use on regular clincher (one piece) rims; they are sometimes used also on quick detachable clincher rims. When used on regular clincher rims it is desirable for sizes including the 4 inch and above to use clips or stay bolts to hold beads securely in rim clinches. **When using regular clincher tires on quick detachable clincher rims,** it is necessary to use flaps to protect the inner tubes.

Fig. 9—Straight side or straight bead cases have non-stretchable cables imbedded in the base and are designed only for quick detachable straight side rims and split type of straight side rims. This style should always be equipped with flaps. Straight side tires are sometimes used on quick detachable clincher rims having fillerbeads fitted in clinches of rims. This is not to be recommended, however, as the base width of this style of rim is not suitable for straight side tires.

CHART NO 286—Rims: One piece Clincher. Quick Detachable Clincher, Quick Detachable Demountable Clincher, Reversible Q. D. Rims. Straight Side Type. The Emergency Tire.

Detaching and Attaching Tires.

Clincher tires of the plain one piece rim **e shown** in chart 236-D.

Quick detachable side ring type; where **e rings** are removed in order to remove **re is shown** in fig. 3, chart 236-B and fig. **2, chart** 236-C. This type of rim can be de**ountable** or permanently fastened to wheel **s per figs.** 2 and 3, chart 236.* The tire **an be** removed, on or off the wheel, if de**ountable**, as per A, B and C, chart 236-AA.

Quick detachable demountable split rim ype; with this type it is necessary to de**ount** rim in order to take tire off. See **g. 4, chart** 236-B and fig. 2 and figs. 1 to **0, chart** 236-C.

It is well to note that **a** Q. D. clincher **ire bead** is very similar to the regular clincher tire bead, but there is a slight difference.

Tire Beads.

A clincher tire for the plain one piece clincher rim has a flexible bead. (page 552).

A clincher tire for the quick-detachable rim has a **hard** bead.

Any clincher tire with flexible bead will fit a Q. D. clincher rim, but a hard bead Q. D. clincher tire will not fit a plain clincher rim. It has been done after considerable work but with injury to tire.

A straight side bead is shown in fig. 9, page 552.

Straight side tires, in emergencies, have also been used on clincher rims, with the use of a filler bead.

†Proper Air Pressure.

There are four ways in which you can save on tire bills; first, by keeping the tires at all times well inflated; second, by using your brakes **with caution**; third, by not overloading the car; **fourth** by repairing small cuts in the tread as they **appear** and being sure wheels are in alignment.

More than three-fourths of all tire trouble is caused by under-inflation. A soft tire by having **its sides** bent at a sharp angle, will soon have **its fabric** loosened from the rubber, with consequent liability of an early rupture. Besides, a **hard** tire presents less surface to the road and is therefore less likely to suffer cuts and punctures.

One manufacturer gives the following rule for inflation of tires. The pressure of air to be carried is about 18 pounds per inch (cross section); for instance, a 3-inch tire ought to have 54 pounds and a 3½-inch, 63 pounds, and so on. The pressure can be accurately tested with a pressure gauge, a good form being shown in chart 238.

Another manufacturer gives this schedule as per chart 236-A. In addition, the **wheel load each** size of tire is supposed to carry and how to figure the wheel load is given.

The most important thing to fix in mind on the subject, is that load as well as **inflation**, must be considered to get good results. These two factors are interdependent. You cannot consider one properly without regarding the other.

If you increase the load imposed on a given tire you must increase the inflation pressure—and vice versa—if you are to maintain this proper degree of flattening.

From this it will be seen that there is no fixed pressure than can be set as standard for any size of tire regardless of load.

That the inflation pressure should vary in tires of a given size according to the load they are obiged to carry, is obvious when you consider, for instance, **a 4-inch tire used on a heavy touring car and another 4-inch tire used on a light roadster.** Obviously the weight on the former is a great deal more than that on the latter, so that the former tire will be flattened or distorted a great deal more, providing tire pressure is the same. In order to prevent this flattening from becoming abnormal and in that way affecting the tire detrimentally, it will be necessary to maintain a higher inflation pressure in the touring car than used in the tires on the light roadster.

If the tire is inflated so that it does not flatten at all under the load more service will probably be received from it. However, this will cause the car to ride harder.

If the tire is underinflated, that is, if the amount of air allows too great a degree of flattening, the constant distortion at its point of contact with the ground as the wheel revolves, will generate heat in the side walls of the tire. This heat destroys the rubber between the individual plies of fabric and tends to separate them. Separation of this kind weakens the tire so it is not long able to stand up under ordinary road conditions.

To Get Better Cushioning; Change to Oversize.

If it is desired to increase the durability or mileage from the tires, the inflation pressure should be increased. In extreme cases where better cushioning effect is desired this can be done by decreasing the inflation pressure. However, that is bound to cut down the mileage received from the tire. The best way to get **better cushioning is to change to oversize tires** because in that case a lower inflation pressure can be used. For instance:

Suppose that a 4-inch tire carrying a weight of 1,000 pounds per wheel should according to the scale, be inflated to 80 pounds. If the motorist found he wished easier riding, the best thing he could do would be to change over to 4½-inch tires, which with a load of 1,000 pounds would need to be inflated to only about 70 pounds.

The big thing to remember in connection with proper inflation in tires, is that it is underinflation and not overinflation that ought to be guarded against.

Inflation Pressure During Hot Weather.

The subject of whether or not inflation pressure in tires should be reduced in hot weather is a very interesting one, because it is generally supposed the pressure should be reduced in the summer time.

In a test made with a 33 by 4 tire on the hottest day ever recorded here in June, we found that although driven at excessive rates of speed, the increase in inflation pressure amounted to only 4 pounds, which of course, is negligible, because many times 4 pounds would not cause the tire to blow out.

Tire gauges are shown on page 568.

Air Compressors.

Hand tire pumps are made in single and double acting, the most satisfactory type is the double acting, as shown in fig. 4, chart 237.

Power pumps or air compressors are driven in various ways; the spark or impulse pump; friction wheel, the belt or gear driven and electric motor driven pump. Modern cars are equipped with small air compressor driven from the engine

Air compressors for garage use are described under "Equipment for the garage." See chart 237-B for air compressors.

---

*Reversible rim (quick detachable) is shown. An ordinary plain Q. D. rim is often referred to as a clincher rim permanently attached to the felloe, with outer clinch removable. In this case the tire is demounted, but not the rim, and called the side ring type, (see fig. 12 chart 236-C).

†**Cord tires** per page 559 require slightly less air pressure than "fabric" tires.

CLINCHER RIM MEASUREMENTS

Size	Inside Diam. of Rims for Wood Wheels	Diam. of Rim at Tire Seat for Wood and Wire Wheels	Size	Inside Diam. of Rims for Wood Wheels	Diam. of Rim at Tire Seat for Wood and Wire Wheels
26 x 2½	20.834″	21	34 x 3	27[illegible]″	28
28 x 2½	21.834″	22	36 x 3	29[illegible]″	30
30 x 2½	23.834″	24	28 x 3½	20[illegible]″	21
32 x 2½	26.834″	27	30 x 3½	22[illegible]″	23
34 x 2½	28.834″	29	32 x 3½	24[illegible]″	25
36 x 2½	30.834″	31	34 x 3½	26[illegible]″	27
26 x 3	19.834″	20	36 x 3½	28[illegible]″	29
28 x 3	21.834″	22	30 x 4	21[illegible]″	22
30 x 3	23.834″	24	32 x 4	23[illegible]″	24
32 x 3	25.834″	26	34 x 4	25[illegible]″	26
34 x 3	27.834″	28	36 x 4	27[illegible]″	28
36 x 3	29.834″	30	28 x 4½	18[illegible]″	19
26 x 2½	20[illegible]″	21	30 x 4½	20[illegible]″	21
28 x 2½	21[illegible]″	22	32 x 4½	22[illegible]″	23
30 x 2½	23[illegible]″	24	34 x 4½	24[illegible]″	25
32 x 2½	26[illegible]″	27	36 x 4½	26[illegible]″	27
34 x 2½	28[illegible]″	29	28 x 5	17[illegible]″	18
36 x 2½	30[illegible]″	31	30 x 5	19[illegible]″	20
26 x 3	19[illegible]″	20	32 x 5	21[illegible]″	22
28 x 3	21[illegible]″	22	34 x 5	23[illegible]″	24
30 x 3	23[illegible]″	24	36 x 5	25[illegible]″	26
32 x 3	25[illegible]″	26	40 x 5	29[illegible]″	30

Note that the 28 and 30 x 2½ Tires are made interchangeable with the 28 and 30 x 3 Tires

The above table gives the clincher rim inside measurement, useful for fitting rims to wheels.

AIR PRESSURES AND CARRYING CAPACITIES OF PNEUMATIC TIRES

(Per Wheel—Car Empty)

	Air Pres're	Rear	Front
28x3″..	50 lbs.	350 lbs.	450 lbs.
30x3″..	"	375 "	475 "
32x3″..	"	375 "	475 "
34x3″..	"	400 "	500 "
36x3″..	"	425 "	525 "
29x3½″	60 lbs.	450 lbs.	550 lbs.
30x3½″	"	475 "	575 "
31x3½″	"	500 "	600 "
32x3½″	"	525 "	625 "
34x3½″	"	575 "	675 "
36x3½″	"	625 "	700 "
30x4″..	70 lbs.	550 lbs.	700 lbs.
31x4″..	"	575 "	725 "
32x4″..	"	600 "	750 "
33x3″..	"	625 "	775 "
34x4″..	"	650 "	800

	Air Pres're	Rear	Front
35x4″..	70 lbs.	675 lbs.	825 lbs.
36x4″..	"	700 "	850 "
37x4″..	"	725 "	875 "
38x4″..	"	750 "	900 "
40x4″..	"	800 "	950 "
42x4″..	"	850 "	1000 "
32x4½″	80 lbs	800 lbs.	1000 lbs.
33x4½″	"	850 "	1050 "
34x4½″	"	900 "	1100 "
35x4½″	"	950 "	1150 "
36x4½″	"	1000 "	1200 "
37x4½″	"	1050 "	1250 "
38x4½″	"	1100 "	1300 "
40x4½″	"	1200 "	1400 "
42x4½″	"	1300 "	1500 "

	Air Pres're	Rear	Front
33x5″..	90 lbs.	950 lbs.	1200 lbs.
34x5″..	"	1000 "	1250 "
35x5″..	"	1050 "	1300 "
36x5″..	"	1100 "	1350 "
37x5″..	"	1150 "	1400 "
38x5″..	"	1200 "	1450 "
39x5″..	"	1250 "	1500 "
41x5″..	"	1350 "	1600 "
43x5″..	"	1450 "	1700 "
36x5½″	95 lbs.	1250 lbs.	1500 lbs
37x5½″	"	1300 "	1550 "
38x5½″	"	1350 "	1600 "
40x5½″	"	1450 "	1700 "
37x6″	100 lbs.	1350 "	1600 "
39x6″	"	1450 "	1700 "
41x6″	"	1550 "	1800 "

†The pressure to be carried in tires and the wheel-load that the different sizes are intended to carry is shown above.

To find the wheel load for any particular car: First, it is necessary to know the weight of the car, with all the passengers and accessories, water and gasoline tanks filled and on board. After weighing the whole car, weigh back of car. To do this, the middle of the step of the car should be over the edge of the platform scale—if a regular wagon scale is not available.

Weigh the front of the car in the same way, the middle of the step being over the other end of the platform. If this has been carefully done, the last two weights added together should give within twenty pounds of the total weight of the car when weighed complete. Of course the wheel loads are one-half of the respective axle loads as found in this way. In this way you can see if your car is tired properly by referring to the scale showing the size of tire to use.

Oversize tires: All tire makers agree that a larger size tire, giving a larger air cushion, is better than a smaller tire with a smaller air cushion. If you think your tires are too small, place a larger size tire on the rim. (See list above "Standard Oversize Tires.")

You can figure the oversize tire your rim will take by adding one-half inch to the cross-section and one inch to the diameter. For instance, suppose your present tire is a 32x3½; by adding one inch to the diameter we have 33 and adding one-half inch to the cross-section we have 4, therefore a 32x3½ rim will take an oversize tire 33x4.

Transposing tires: Ruts, curbings and similar tire destroyers may wear the outer wall of a casing nearly to the fabric, but if the tire is reversed, and that side which has been exposed and most worn placed nearest the car, it will still be serviceable.

As the rear tires sustain more than half the bur in every movement of the car, they will wear rapidly than the front tires; they also have to b the traction strain, that of carrying the car forw and for these reasons they are subject to more than the front tires. Furthermore whenever the ca stalled in a mud hole, the rear wheels revolve a g many times without the front ones moving.

Many motorists follow the practice of using tires on the front wheels and new ones on the wheels. Increased service can also be had by tra posing tires. In ordinary wear it is usually true tires on the right side become worn more qu than those on the left. This is due to their being into ruts and stones, when the car is turned out of traveled roadway, and because the tires of the side suffer most from curbings and the like as driver uses the right side of the street, they also more than half of the weight when the car leans it does mostly on the right side.

The right rear tire wears faster because of the of the streets and roads. The weight being mor the incline is probably the cause.

S. A. E. STANDARD SIZES OF PNEUMATIC TIRES FOR PLEASURE CARS

Rim Sizes	Even Tire Sizes (for manufacturers and consumers)	Odd or Oversize Tires (for consumers only)	Tire Seat Diameter
30x3	30x3	31x3½	24″
30x3½	30x3½	31x4	23″
32x3½	32x3½	33x4	25″
32x4	32x4	33x4½	24″
34x4	34x4	35x4½	26″
34x4½	34x4½	35x5	25″
36x4½	36x4½	37x5	27″
36x5	36x5	37x5½	26″
38x5½	38x5½	39x6	27″

See bottom of page 555 for change of tire siz

STANDARD OV
TIRES

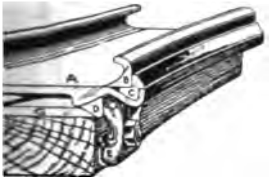
Standard Tire Sizes
28x3 takes....
28x3 takes....
30x3 takes....
30x3 takes....
32x3 takes....
34x3 takes....
36x3 takes....
30x3½ takes....
32x3½ takes....
34x3½ takes....
36x3½ takes....
32x4 takes....
34x4 takes....
36x4 takes....
34x4½ takes....
36x4½ takes....
38x4½ takes....
40x4½ takes....
42x4½ takes....
36x5 takes....
36x5½ takes....
38x5½ takes....
40x5½ takes....

*METRIC TIRE EQUIVAL

Metric Sizes
650x 65
700x 65
750x 65
800x 65
830x 65
860x 65
700x 85
750x 85
800x 85
860x 85
760x 90
810x 90
840x 90
870x 90
910x 90
960x 90
1010x 90
815x105
875x105
915x105
820x120
850x120
880x120
920x120
1020x120
1080x120

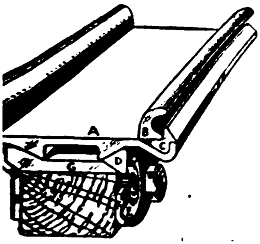
CHART NO. 236-A—Useful Information Relating to Tires.

*Figures in 1st column represent milli-meters. See page 541 for explanation of milli-meters. †See page 550 for pressure to be carried in cord tires.



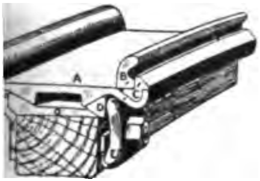
Type A

e A — Firestone Rim. detachable and de- table. This rim takes a "clincher" or a "quick hable clincher" tire. can be removed without ring rim, or the rim and an be demounted.



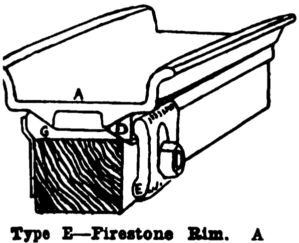
Type B

ype B — Firestone Rim. also a quick detachable, ountable rim, but the side ; (B) can be reversed for with any straight side or D. tire. Therefore this rim take a plain "clincher" "quick detachable clincher" "straight side" tire. By oving the clamp the rim h tire is demountable.



Type C

Type C — Firestone Rim. ick detachable, demount- le for use with any standard straight side" tire. This a quick detachable rim with mountable features.



Type E—Firestone Rim. A emountable rim for straight ide tires. It is a split rim, e figs. 4 and 5, chart 236B.

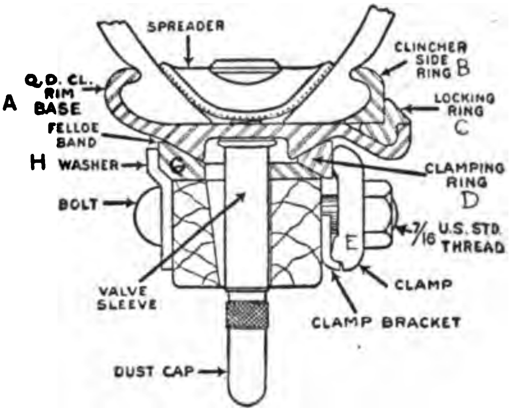


Figure 1

Be sure that valve sleeve, sent out with every set of Firestone demountable rims, is being used. This is an important feature of this rim as it serves to hold steel valve spreader securely in place, making it impossible to throw a tire even when deflated, prevents moisture from working into the tire around the valve stem, and the dust cap need not be removed when the rim is mounted or demounted.

*Quick Detachable Rims.

Type A—Firestone Quick Detachable, Demountable Rim: A—Rim Base. B—Side Ring. C—Locking Ring. D—Clamping Ring. E—Clamp. F—Clamp Bracket. G—Felloe Band. H—Bolt Washer.

Type B—Firestone Quick Detachable Reversible Demountable Rim. A—Rim Base. B—Reversible Side Ring. C—Locking Ring. D—Clamping Ring. E—Clamp. F—Clamp Bracket. G—Felloe Band. H—Bolt Washer.

Type C—Firestone Quick Detachable Demountable Rim: A—Rim Base. B—Side Ring. C—Locking Ring. D—Clamping Ring. E—Clamp. F—Clamp Bracket. G—Felloe Band. H—Bolt Washer.

Type E—Firestone Demountable Split Rim: A—Straight Side Split Rim Base. D—Clamping Ring. E—Clamp. F—Clamp Bracket. G—Felloe Band. H—Bolt Washer.

Partial List of Prominent Users of Firestone Rims.

Chandler Motor Car Co., Indianapolis, Ind., 34x4 E. Lt.
Haynes Automobile Co., Kokomo, Ind., 34x4 E. Lt.
Hupp Motor Car Co., Detroit, Mich., 34x4 E.
Locomobile Company of America, Bridgeport, Conn., 36x4½ A.
National Motor Vehicle Co., Indianapolis, Ind., 34x4½ A.
Packard Motor Car Co., Detroit, Mich., 34x4½ and 36x4½ A.
Paige Motor Car Co., Detroit, Mich., 32x4 E. Lt.
Premier Motor Car Co., Indianapolis, Ind., 34x4 E-Lt.
Republic Motor Truck Co., Alma, Mich., 34x4½ A.
The White Co., Cleveland, Ohio, 32x4 and 36x4½ A.
Winton Motor Car Co., Cleveland, Ohio, 36x4½ A.

Change of Tire Sizes by Order of Conservation Division of War Industries Board.

Standard sizes of tires which were discontinued during war period are as follows: 30x3½ clincher; 32x3½ straight side; 31x4 clincher; 33x4, 34x4½, 35x5, 36x6, 38x7, 40x8 straight side. Above sizes will be made in plain and non-skid tread. **The sizes discontinued Nov. 1918**, are as follows: 30x3½, 35x4, 37x4½, 29x4½ straight side, non-skid and 33x5 straight side plain; 32x3½, 33x4 Q. D. non-skid and clincher non-skid; 32x4½, 33x4½, 34x4½ Q. D. non-skid; 36x4½ Q. D. non-skid and straight side plain.

Sizes to be discontinued Nov. 1919, are 33x4½ straight side, plain tread; 36x4½ straight side, non-skid; 35x4½, 37x5 Q. D. non-skid. Other sizes will be discontinued by Nov., 1920.

It will be observed that the first six sizes of tires to be continued will fit three sizes of rims. For instance, 30x3½ rim will take 31x4 clincher; 32x3½, a 33x4 straight side; 34x4½, a 35x5 straight side.

RT NO. 236-AA—Examples of Quick Detachable Demountable Type of Rims (Firestone) on type A, B, and C rims, the tire can be detached from rim without demounting rim from wheel. The demountable feature is retained by all rims.

a straight side rim is the popular rim

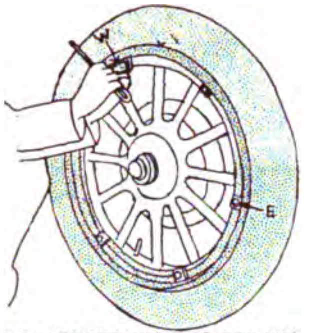


FIG. 1 - TO DEMOUNT TIRE AND RIM LOOSEN SIDE CLAMP "E" WITH SOCKET WRENCH "W"

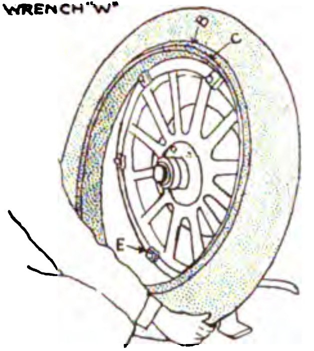


FIG. 2 - DEMOUNTING RIM, TIRE AND ALL FROM WHEEL

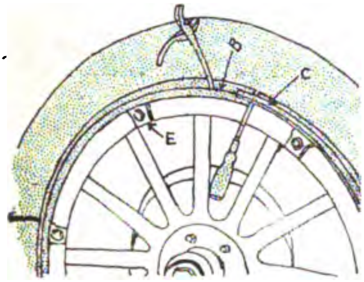


FIG. 3 TO REMOVE TIRE FROM RIM PRY OFF LOCKING RING C

Demounting and Mounting Q. D. Tires Side Ring Type.

To demount the rim from the wheel (applying to type A, C): Jack up wheel and loosen clamps (E) using the wrench (W) which accompanies each set of rims. Slide each down as far as it will go (fig 1), then tighten nut hold clamp in that position.

The socket wrench supplied may be operated with while the other hand is employed to steady wheel. See fig. 1.

When all clamps have been freed, turn the wheel so valve stem is at top, then swing out lower side of rim (fig. 2) rim, tire and all, off the wheel.

The valve hole in felloe is tapered so this can be done straining the valve stem. Note—It is not necessary to cap when demounting rim. Dust cap should always be kept tightly against the valve sleeve, except when detaching the its rim.

To mount the spare rim with inflated tire (applying A, B and C.). Having taken clamping ring from rim just place in same position (with point toward inside) in spare ing inflated tire.

Turn the wheel so that the valve hole in felloe is at the insert valve stem (with dust cap and valve sleeve already through hole and swing the lower part of rim snugly into Ends of clamping ring should come under one of the clamps.

Restore each clamp in turn to its original position, ping the clamping ring, giving the respective nuts one or two with the wrench to hold the clamp fairly tight. Then continue the wheel again, tightening down all nuts and clamps firmly.

To apply the tire to A, B or C rims: Place the slightly flated inner tube in the casing. using plenty of soapstone and set casing back on rim.

Put on the clincher side ring. Apply locking ring by the pin in notch in edge of rim and then force the locking into its groove around the wheel. Inflate tire to proper pressure.

Screw dust cap on tight against valve sleeve.

The spreader is held in position in the base of the the pressure of screw dust cap against valve sleeve. No nut or other device is necessary.

To remove tire from types A, B or C rims: Remove cap and allow the air to escape. Push the valve stem up the tire as far as it will go, thereby releasing the pressure spreader inside.

Insert point of screw-driver between side ring (B) and ring (C), fig. 3). Pry downward, causing an opening between the rings. Drop a coin or other convenient piece of metal into this ing and hold opening thus gained. Pry downward with screw- which will remove locking ring (C). Bead ring and tire may removed from rim. Note valve sleeve will remain in valve hole or felloe.

Demounting and Applying; Split Rim (Type E).

The type E rim, figs. 4 and 5, are the split type. To loosen clamp bolts.

To remove tire from type "E" Firestone rims without operating tool: Be sure cam button lock (T) is unlocked. This of rim is split (at R) and a button which is slotted and inner side of ring is operated with a screw driver. To prepare for removing tire, turn button so flat edge (not shown) is parallel end of latch. Grasp tire in both hands and strike firmly on at a point indicated by S, causing rim to collapse, as indicated in Then turn tire half way around position as shown in fig. 4. your weight onto rim, and tire be pulled off with hands. Or screw driver, or similar tool both beads, and tire may be off with ease.

To apply tire on type E rim out rim tool: After collapsing rim in manner of fig. 4, lay rim ground, insert valve stem in hole rim, stand on beads of tire "walk" same over flange of working to the right from around rim. Note fig. 5.

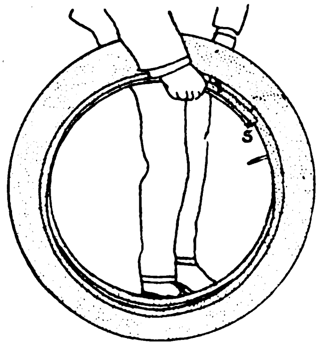


FIG 4-TO REMOVE TIRE FROM TYPE "E" RIMS WITHOUT AID OF OPERATING TOOL

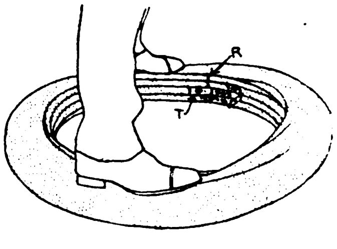


FIG. 5-TO APPLY TIRE TO TYPE "E" RIM WITHOUT RIM TOOL.

CHART NO. 236-B—Demounting Rim, Mounting Spare Tire, Applying Tire to Rim—of Type A and C Firestone Rim as an Example. Demounting Type E Rim.

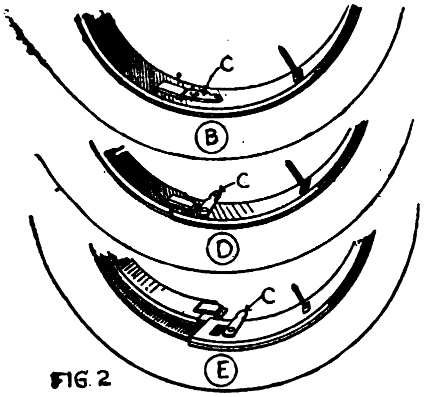


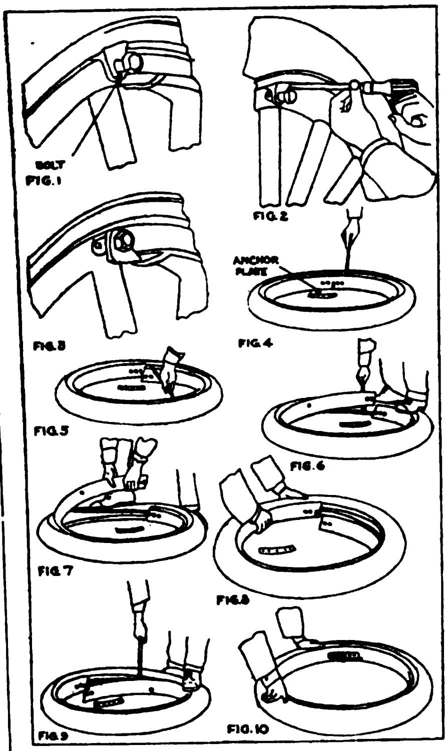
FIG. 2

The Split Rim.

In fig. 2 a split rim is shown with a locking lever C. The rim is called a split rim because it is not endless but is cut through on one side. When rim is removed the locking lever (C) is thrown to one side as at (D). The rim is then pried out or lapped (E) and tire pulled off.

When rim is put back in place the lever C is put in place as at (B). The type E rim chart 236-B is of the split type but has a different locking device.

Another type of split rim is shown below in figures 1 to 10 and is similar but a different locking principle. We will use this type below to explain how the rim and tire is demounted; how tire is removed from rim and how replaced. The procedure is very similar on all types of split rims.



The Baker bolted-on type split rim—used on the Buick as example, see figures 1 to 10.

The demountable rims supplied with Buick cars are known as the Baker bolted-on type and may be removed from the wheel with the tire. The operation is as follows:

To demount rim and tire: With the brace wrench, loosen all bolts about ¾ inch, (fig. 1) except the ones on each side of the valve stem. Insert screw driver at right hand side of wedge, between rim and wheel (fig. 2), and strike handle of screw driver to free the wedge. When free, turn wedge around, (fig. 3), and tighten bolt to hold wedge in this position so it will not interfere with rim while dismounting.

To take rim out of tire, lay rim and tire flat (fig. 4), so that the end of the cut in rim farthest from the valve stem is up. Remove anchor plate and beginning at end of rim which does not have the valve stem, insert sharp end of tire tool under bead of tire. Force down end of tire tool in hand (fig. 5), until end of rim is out of tire. This will bring the two short sides of the rim together, thus reducing its circumference. Repeat operation, as necessary, to free rim. Next, turn rim and tire completely over (fig. 6), and force tire tool between both beads of tire and rim, then holding tire with the foot (fig. 7), grasp free end of rim and pull it out of the tire.

To replace tire on rim, lay rim flat on the ground with tire on top (fig. 8). Raise end of rim which is drilled for the valve stem, and after valve stem has been inserted, put both beads of tire entirely into the end of rim that has been raised, making sure that other end of rim is under both beads of the tire. After the beads of the tire have been properly started, insert them all the way around, leaving other end of rim to be put in last. If the tire is too stiff to force on by hand, use tool, fig. 9. Add anchor plate and valve cap after inflating (fig. 10).

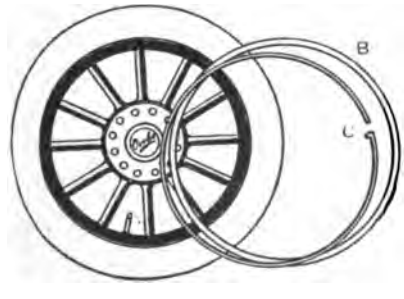


Fig. 12. Side ring type of Q. D. rim. B—is the endless ring. C—is the other.

Demounting Side Ring Type.

Fig. 12—This type of rim is the side ring type of quick-detachable demountable rim, similar to fig. 3 chart 236-B The illustration shows the locking ring (C) and side ring (B) removed and tire ready to be removed from rim, see also chart 236-AA.

When replacing, push the casing back as far as it will go; replace the side ring (B) and finally the locking ring (C), by first inserting the stud of the latter in the hole and working the ring all around into the groove.

The locking ring is inserted most easily while the casing is being pushed back as much as possible. When this is done in the proper manner it is not necessary to use a hammer in order to seat the ring into its groove.

CHART NO. 236-C—The "Stanweld" Rim. The Quick Detachable Type of Rim with a Locki Ring. The "split" rim must be removed from wheel to remove tire. In type shown in fi 12, called the "side ring" type, the tire can be removed with rim on wheel, or demounte

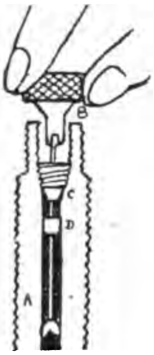


Fig. 2—Shows how the valve cap B is reversed to unscrew the inner valve when tube is to be deflated.

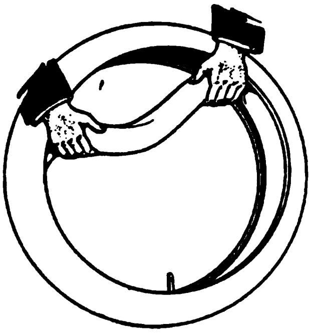


Fig. 3-A—Replacing inner tube.

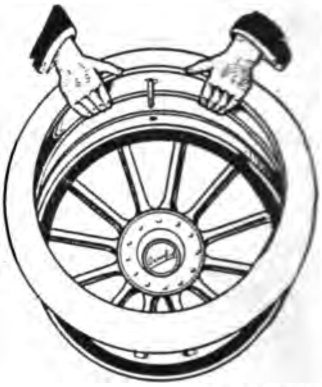


Fig. 2-A—Removing inner tube from tire.

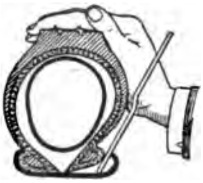


Fig. 1—The First Operation in removing a tire cover: After the lug bolt wing nuts have been slacked off, the edge of cover is pushed out of the rim and the tire levers inserted.

Various forms of levers are obtainable, some being more convenient to use than others. Most of the tire makers supply suitable levers for their tires.

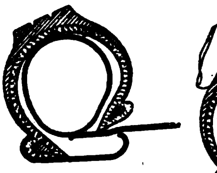


Fig. 2—Second Operation: The lever raising the cover over the edge of the rim. Special care must be taken not to pinch the air tube between rim and lever. This would result in damage to the tube, rendering it useless till repaired. Even if not cut through, the rubber would be so much weakened as to burst under the effect of air pressure on some future occasion.

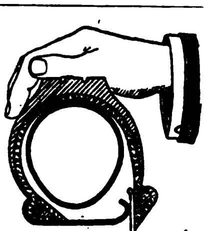


Fig. 3—Third Operation: The hand is used in assisting the working of cover down outside of the rim, the lever being in position between cover and rim. A new cover will generally be found stiff to manipulate with the hands for the first time, but soon becomes supple with use

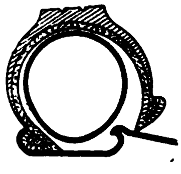


Fig. 4—Fourth Operation: The inner tube having been carefully replaced, the hooked end of the lever is used to work the edge of cover back into the rim.

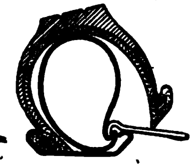


Fig. 5—The Inner Tube has been pinched by tire tool

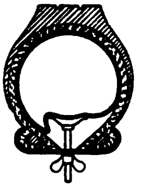


Fig. 6—Illustrating a serious fault. The inner tube has become nipped between one of the lug bolts and cover, and unless released will result in a burst tube. This risk is avoided by taking care to moderately inflate tube before replacing in cover.

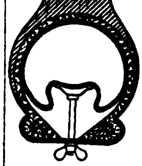


Fig. 7—Illustrating how the Security Bolt, by being pushed towards inside of tire before screwing down, allow cover and tube to fit into the correct position. The ordinary security bolt has a canvas-covered bead which sometimes causes air tube defects, such as nipping and chafing. If bolts with moulded rubber heads be used these defects are not likely to occur.

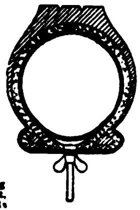


Fig. 8—Illustrating the Tire properly Fitted, the security bolts in place, and inner tube snugly in its place, no nipping at any part. The tire when pumped up should be even all the way round the rim, and run truly when the wheel is rotated.

Above illustrations show how to remove and attach a tire on a "one-piece" clincher rim.

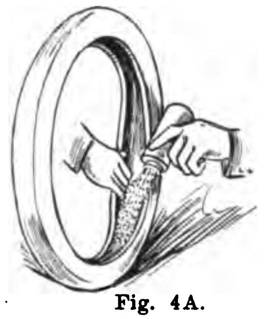


Fig. 4A.

To Remove an Inner Tube.

Jack up wheel. Remove the valve cap and inside valve by reversing the cap head and unscrewing it as shown in fig. 2. Remove lock nut on valve stem (see (H) fig. 6, chart 235).

Push edge of casing from under the lip of rim with tire tool as shown in fig. 1. Pry off as in fig. 2 and 3. This operation must be repeated all around the tire until the outer bead is loosened. The inner tube can then be removed and outer casing slipped off.

When taking an inner tube out of tire, turn the wheel until the valve stem is at the bottom, as in fig. 3-A, remove the tube, beginning at top.

Always make it a point to run your hand around inner tube in the casing until you detect the cause of the puncture, because very often the offending object is hidden in tire and cannot be seen or felt from outside.

Replacing Inner Tubes.

Put in a new tube, or patch the old one in accordance with the instruction further on; the **inserting of the tube may be done with the casing remaining on the rim or with it removed.** In either case it is desirable to turn the wheel until the valve stem hole is on top (fig. 2-A). Before the tire is replaced, the inner tube should be slightly inflated.

Place powdered soap stone or mica in case before inserting tube, fig. 4-A. (Too much of this however is likely to work up into little balls and cause inner tube trouble.)

Then run your hand around the inner tube, smoothing out the creases and placing the tube evenly around the rim.

Do not inflate the tube too much when placing it in a tire, for if you do, you will have difficulty in replacing the locking rim over the bead of the casing.

Inflate the tire carefully after it is properly attached, and test the increasing pressure with your hand.

Occasionally the tube is pinched under the spreader. Push the valve stem up and down with your hand before inflating. When the valve returns to its original position there is no danger of pinching.

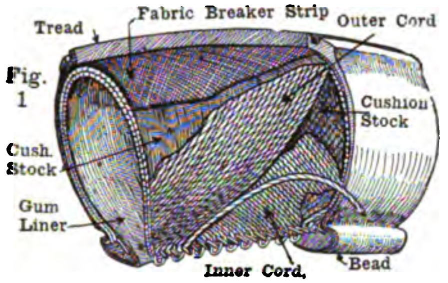
CHART NO. 236-D—Removing and Replacing Inner Tubes. Removing and Replacing the Clincher Tire on the "one-piece" Clincher Rim. The "one-piece" plain clincher rim is now seldom used.

The Cord Tire.

The cord tire differs from the fabric tire previously described in that instead of sea island cotton or other closely woven and interwoven fabric being used for the carcass of the tire, cords are used which are loosely woven and not interwoven.

There are two kinds of cord tires, the "cable cord" and the "multiple cord."

The cable cord tire is known as the Silvertown cord tire and is a product of the Palmer Tire Co. of England made in a suburb of London called Silvertown. This tire is made in this country by the B. F. Goodrich Co., the Carlise, and Fiske.



The multiple cord tire is made by the Firestone, Goodyear and some of the other tire manufacturers.

The difference between the cable cord and the multiple cord tire is in the size of the cords and the number of plies of cords. In the **cable cord tire** there are two to four plies of heavy cable cords.

In the **multiple cord tire** there are 6 to 8 layers or plies of smaller cords or threads.

The cord tire is far stronger than the fabric tire, one principle reason being that the cord tire is not so closely woven or **interwoven** as the fabric carcass tire and therefore not broken so easily, as with the fabric tire it is continually sawing itself as if it were being bent back and forth and eventually breaks. Another advantage is that a cord tire is not subject to stone bruises as explained on page 566, as the cords all run one way and are not interwoven as fabric, and the result is they will give without breaking when tire strikes a stone at high speed, or in other words, the carcass will have same action as the tread—it will stretch under blow without breaking.

For an example of the construction of the cord tire we will use the "cable cord" tire as an example per fig. 1.

The **inner lining** of a tire is made of a rubber sheet, then the first or **inner layer or ply of cable cord** is laid and then two sheets of pure gum are applied to act as a **cushion** between this and the next ply of cord. The **second or outer layer of cord** is then applied at right angles or at angle of 45 degrees to the first layer, then two layers of gum **cushion** stock, then a fabric **breaker-strip,** then the **tread.**

The body or carcass of the tire as it will be noted, is made of two plies or layers of cords, instead of fabric. These cords are made of cotton fibre, about the size of heavy sewing cotton, twisted into cords about the size of ordinary grocery store twine, but stronger. These cords in turn are woven into cables.

Throughout the process, all units are impregnated, under heavy pressure (hundreds of pounds to the square inch) with a solution of pure, fine rubber. This has much the same effect as waxing shoemaker's thread. The solution permeates every fibre, being literally driven into it.

Treads: There are two types of treads used on cord tires, the "ribbed tread" per fig. 8A, page 550 and the "safety" or "non-skid" tread.

The air pressure carried in the cord tire is slightly less than a fabric tire, for instance, 3½" size 50 lbs.; 4" size 60 lbs.; 4½" size 70 lbs.; 5" size 75 lbs.; 5½" size 80 lbs.

Cord tires are made in following sizes: *30x3½; *32x3½; *32x4; *33x4; *34x4; 32x4½; 33x4½; 34x4½; 35x4½; 36x4½; 33x5; 35x5; 36x5; 37x5; 38x5½.

Beads of tires are made for Q. D. clincher and straight side rims where marked *, the other sizes are made for straight side rims. Only straight side bead tires will be made in the future.

A heavy truck tire of the cord type is made in 36x6 size. The Firestone Co. make pneumatic cord tires for commercial use in 6, 7, 8 and 10 inches cross section called "Giant Cord Tires."

Airplane tires of the cord type are made in 26x4 and 32x4½ sizes.

The cord tire is a higher priced tire than the fabric tire but is the popular tire, as it will outwear the fabric tire and is well worth the difference. This is due to its strong construction, yet is resilient and easy riding and cords do not break as readily as interwoven fabric.

Cord tires can be made in the "molded" or "wrapped tread" method, per page 565.

Tire Protectors.

There are two methods for making a tire puncture proof:

The steel disc type of puncture proof tire fig. 4 consists of three layers of 5/16" diameter steel discs about 1/64" thick, imbedded in rubber between the fabric and tread of tire. The layers of discs are placed in such a manner that it is impossible for a nail to enter the tread of tire without striking a disc. This tire is called the Lee puncture proof tire.

The leather lined puncture-proof tire consists of a special made tire on the **inside** of which is a puncture-proof strip of chrome leather which is intended to prevent punctures without stiffening the tire. This tire is known as the Woodworth trouble-proof tire.

Another example is the outer leather cover made of water-proof chrome leather studded on the tread surface with steel rivets. These covers completely enclose the tire and are attached to the rim, per fig. 5. The manufacturer claims they are particularly valuable to use over old tires or re-tread and strengthen them and also valuable to people who have to run over roads that are rough, rutty and rocky, and who travel at less than 25 miles per hour.

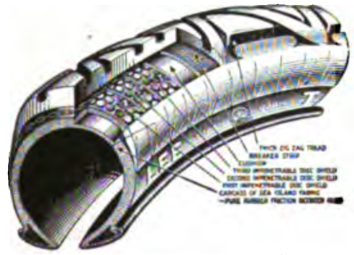

THICK ZIG ZAG TREAD
BREAKER STRIP
CUSHION
THIRD IMPENETRABLE DISC SHIELD
SECOND IMPENETRABLE DISC SHIELD
FIRST IMPENETRABLE DISC SHIELD
CARCASS OF SEA ISLAND FABRIC
PURE RUBBER FRICTION BETWEEN

Fig. 4: Lee puncture proof tire.

Fig. 5.

Spring Covers.

Fig. 6. Woodworth spring cover and lubricator laces over the spring, preventing any danger of moisture or dirt getting between the leaves. The cover is lined with a felt wicking which is saturated with oil before the cover is put on and will hold enough oil to lubricate the springs for 10,000 miles. The smooth gliding effect is obtained which, is so noticeable in a new car with perfectly lubricated springs.

Fig. 6.

CHART NO. 236-E—The Cord Tire. Tire Protectors. Spring Lubricator.

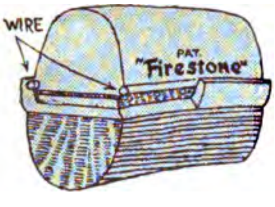


Fig. 1.—Side wire solid tire. The original automobile tire, now used on light trucks, trailers, cabs, horse-drawn vehicles, etc.

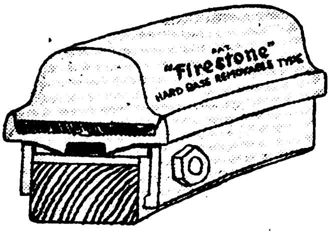


Fig. 3.—The hard base tire on removable rim.

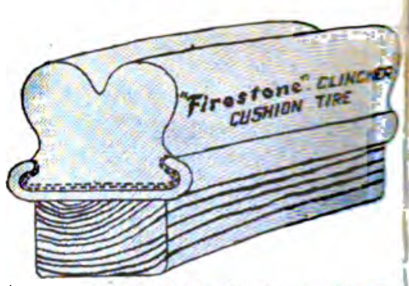


Fig. 5.—Firestone clincher cushion tire interchangeable with pneumatic tires on regular clincher rims.

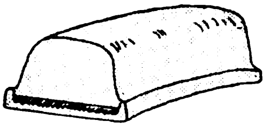


Fig. 2.—The hard base pressed-on type of solid tire.

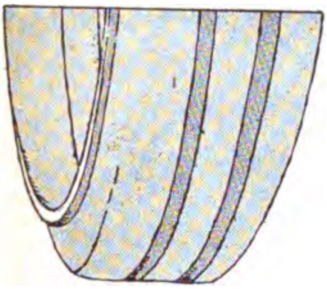


Fig. 4. — The Firestone "Giant" is a tire designed especially for heavy hauling. Made in 8 in. 10 in., 12 in. and 14 in. width treads. It replaces dual equipment for certain classes of heavy service. The tread is grooved.

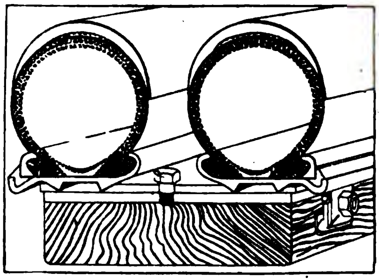


Fig. 7.—Firestone dual pneumatic tires on quick-detachable rims used on heavy cars of high speed.

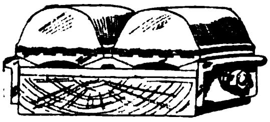


Fig. 11.—Goodyear dual demountable solid tire.

Solid Tires.

Solid tires are used principally on trucks and electric vehicles, and are divided into two classes, as follows: single and dual.

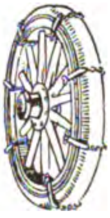
The single solid tire is fitted on different types of rims. On one type the tire is pressed on to the rim as in fig. 2—in another the rim is of the quick-detachable type (fig. 3), and in another the rim and tire is demountable.

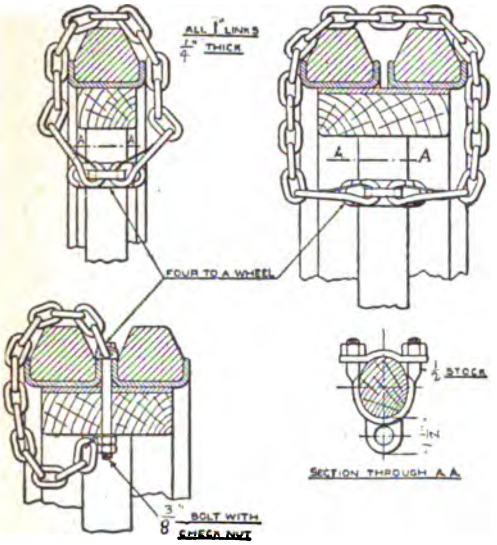
The dual tire is divided into two classes; the block type and solid. The block type is made up of sections. If one becomes damaged it can be re-placed.

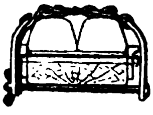
The solid cushion tires are used extensively on electric vehicles.

Size of Solid Tires to Use.

SINGLE		TWIN	
Size Inches	Extreme Load per Wheel Pounds	Size Inches	Extreme Load per Wheel Pounds
2	500		
2½	750	2½	1900
3	950	3	2500
3½	1375	3½	3500
4	1750	4	5000
5	2000	5	6000
6	3000	6	8000
7	4000		



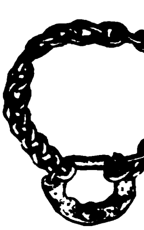




Chains for Solid Tires.

Chains are essential for gripping the road, snow, ice, etc. Several methods of applying chains and grips are shown on this page. The Woodworth Co., Niagara Falls, N. Y. manufacture a good chain grip for solid tires as shown below.

Either twisted links or straight link chains may be used on solid tires as shown. Should be applied at 4 points on each rear wheel. They should be removed when not required. Illustration, below to left, is where clearance will not allow chain on inside tire (Gen'l Vehicle Co.).



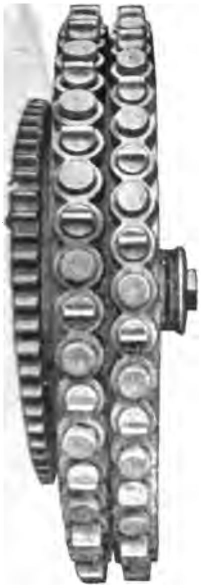
Woodworth chain grip.

*Solid Tire Repairing.

The solid tire cannot be successfully vulcanized. Therefore the only recourse is to run the tire as long as possible. The solid tire business of applying tires and rims is a profitable business.

HART NO. 236-F—Solid Tires. Chains or Grips for Solid Tires.

Solid Tire Troubles are mostly in cuts and bruises which soon causes to wear rapidly—due to—driving in car acks; neglected cuts; chains too tight; out of alignment; skidding; overloading; speeding and bad roads. If ains are used—have them loose.



ig. 5—Special wedge ped and round cast iron gs: The illustration ve shows an Avery cast al rim wheel with wedge ped and round cast iron gs in place of the regu- hardwood plugs. In s case the two styles of n plugs are placed alter- ely. They can be used any manner desired. The wedge-shaped plugs particularly useful and a few of them placed a wheel enables it to travel over much softer muddier roads than otherwise.

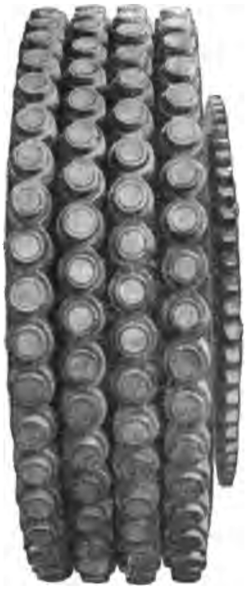


Fig. 4—Wood plug extension rims are made in either a one or two row wood plug extension rim. The single row rim increases the width of the wheel to 9 inches and the double row to 12 inches.

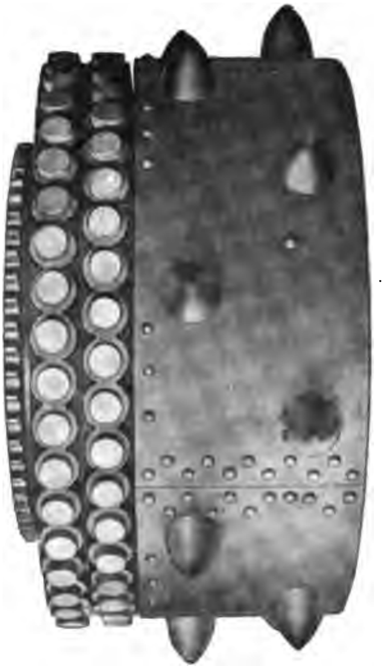


Fig. 3—Flat steel extension rims with heart shaped lugs: The 6 inch pair of these rims placed on the rear wheels increases the face of each wheel to 12 inches; the 12 inch pair increases the face to 18 inches.

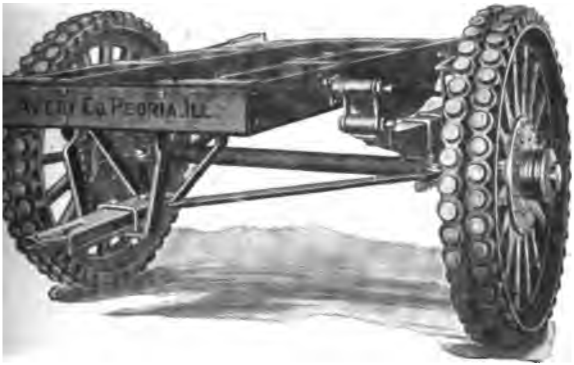


Fig. 6—For coupling on wagons or other machinery to a ruck—this coupling is automatic.

Fig. 2—Automatic paddle wheel extension rims: Automatic a action. They consist of two wrought iron bars between which are heavy cast lugs 8 inches in width. These lugs are iounted on pivots, and the points are held below the surface f the wheel rim by means of springs. When the wheels ravel over muddy roads or soft ground and sink so that the oints of the lugs touch the ground, the revolution of the wheels causes the lugs to be extended vertically 4¼ inches bove the surface of the wheels, forming a solid bearing surface against which to push. They are drawn back by springs and go out of action when not needed, and automatically go into action the moment they are required. The lugs can be fastened permanently in an extended position if desired.

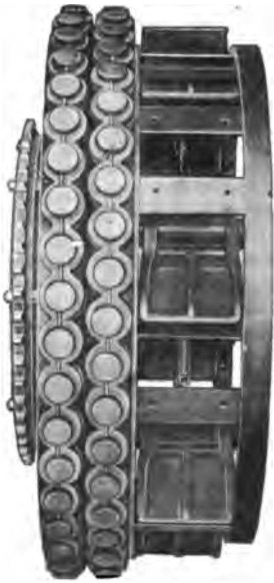


Fig. 2.

ART NO. 230-G—Tires and Wheels for Heavy Duty Truck and Tractor Work. A Coupling.

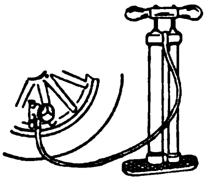


Fig. 3—Showing a compound air pump with an air pressure gauge attached. The gauge shows the amount of air pressure in lbs. per square inch.

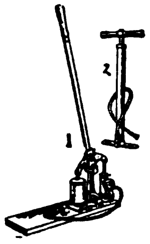


Fig. 1—Two types of hand air pumps.

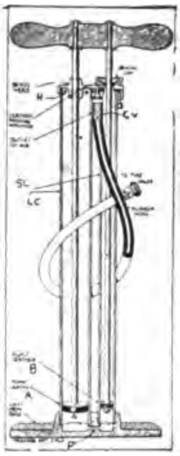


Fig. 4.

Hand and Foot Air Pumps.

Fig. 4—A compound hand air pump principle is th as that employed in a power pump, that is the air is in from atmosphere into large cylinder at (H), compr the down stroke of the handle and at the same time forced into the smaller cylinder at (P). The up of the pump forces the air from smaller cylinder into tire through check valve and hose (CV) and large cyl sucks in another charge. While the air admitted into large cylinder is receiving its first compression, it is through passage (P) (connecting the two cylinders) past cup leather (B) into the upper portion of the cylinder. The cup leathers (A) and (B) are fitted to pistons in opposite positions, that is, the leather (A) is in with its open side downward and leather (B) has its side upwards. If both leathers are put in the same the pump will not work. A pump of this kind differs single sylinder pump, in that each stroke is a power whilst in a single cylinder pump only the down stroke power strokes. Keep leather packing washer (around rod of small cylinder) tight, otherwise the air will through here instead of going into the tire.

Every up stroke of piston (B) forces into tire as of air equal to the volume of the large cylinder at pheric pressure.

The same principle applies for using a two-cylinder compound tire pump instead of a single-cylinder one, plies in the use of a two-cylinder or compound steam

There is also another type of compound hand pump on the market differs with the above, in that it is double acting as well as compound— pistons working in both directions of stroke. While the air is receiving first compression, it is lead through a by-pass to upper portion of small cyl instead of the lower. The hose connection is at the bottom instead of at the

The Spark Plug or Impulse Pump.

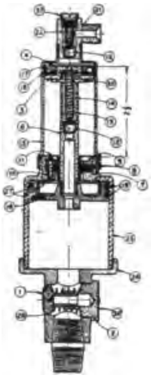


Fig. 5—The spark plug or impulse pump, as it is sometimes called, is of the type which screws into a spark plug hole and operates through the compression of the engine.

1—Inlet valve disc.
2—Inlet valve body.
3—Upper piston.
4—Upper piston nut.
6—Piston rod.
7—Stuffing box.
8—Rod packing.
9—Rod packing nut.
12—Ball check valves.
13—Upper piston pin.
14—Check valve spring.
15—Upper cylinder shell.
16—Lower piston.
18—Piston cup leather.
19—Piston rings.
21—Outlet valve.
22—Outlet valve spring.
23—Outlet valve cap.
24—Cylinder base.
25—Lower cylinder shell.
26—Inlet valve seat.

Fig. 5—This pump has the appearance of a compound pump, due to large and small cylinders, but they are built thus to make it possible to the high pressures necessary for large tires, and at the same time not any too good compression in the engine cylinder. The lower piston with large area, receives its impulse from the compression in engine cylinder, transmits it to the upper piston through the medium of the hollow piston to which both pump pistons are attached.

Action—as the engine piston makes its suction stroke, it draws fresh through valve (1) which opens inwardly, and at the same time, both pump pistons make their downward stroke. You will note that piston rod (6) is hollow, this is the air passage to upper cylinder through ball check (12). As the engine piston makes its compression stroke, it forces its charge of compressed air into the upper cylinder and against lower piston of pump and causes it to make an upward stroke, this piston being so much larger than the upper piston, the charge is further compressed and sent through outlet valve (21) at the top, thence through hose to tires or tank.

These pumps are very often spoken of, as compound pumps, due to the fact that the air pressure is raised in two stages, but don't forget that the first stage is performed in the engine cylinder and not in the pump cylinder. It is a single stage pump, capable of raising the pressure from 50 or 60 lbs. in engine cylinder, to 100 lbs. or more in tire or tank.

It is advisable to let the pump make a few strokes, before attaching hose, to tire valve.

Power Driven Tire Air Compressor.

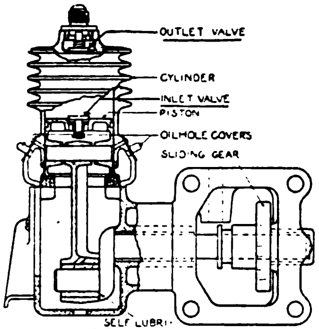
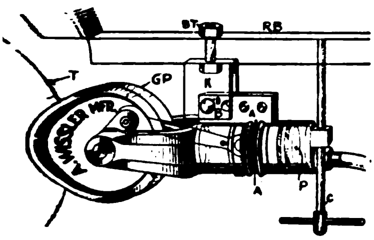


Illustration is of the compressor used on Cadillac car. It is bolted to left side transmission case and driven by a sliding gear which meshes with reverse idler gear in transmission. The sliding gear is thrown in when needed and out when not needed, by a lever.

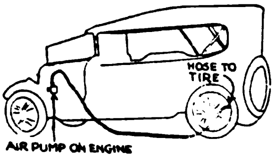
To operate; stop engine, wait until transmission gears are idle, then shift gear of compressor in mesh with the reverse idler gear. Then start engine, being sure gear shift lever is in neutral position.

Run engine at speed of 900 to 1100 revolutions per minute. This is indicated by ammeter showing 16 or 18 amperes, if third brush is properly regulated on generator. Do not race engine when inflating tires. Throw gear out of mesh when through pumping tires. Lubricate compressor often. By observing illustration the inlet of air is taken in through "inlet valve" in top of piston, from crank case of pump, when piston travels down. It is compressed and forced out the "outlet valve" as piston travels up.

CHART NO. 237—Air Pumps; Hand and Power Types.

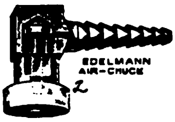


8——Wissler friction drive air pump—
; **GP**—grooved pulley on pump con-
rod; **K**—bracket bolting pump to
g **board; A—air intake; P—** piston;
ustment of tension of GP to T. The
heel is jacked up—engine run on low or
: gear. (Wissler Inst. Co., St. Louis.)



Illustrating how the connection from air pump (driven from engine spark plug or friction pump) to tire is made. The air hose is detachable and usually carried under the seat.

Figs. 1 and 2 illustrate large hose couplings for garage use.

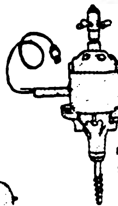


For air lines a special heavy connection for the air hose is necessary. For placing over tire valve for inflating tires. Made to fit 5-16 and ½ inch hose. Two types of connection are shown.

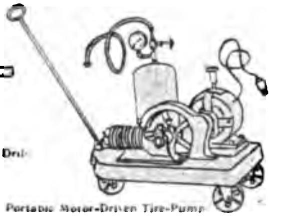
pairing Shoe With the Westinghouse Vulcanizer

Cleaning Car With a Motor-Driven Vacuum Cleaner

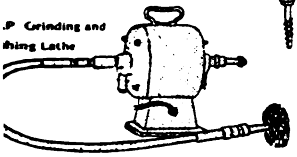
nizing Inner Tube



Portable Electric Drill



Portable Motor-Driven Tire-Pump



.P Grinding and shing Lathe

Air Compressors.

***A portable air compressor outfit is here shown; and can be moved to different parts of the garage.**

The attachment plug is screwed into a lamp socket which operates the electric motor. This operates the air compressor which stores air into the tank. The advantages are apparent.

Compressed air for cleaning the upholstering is used in many up-to-date garages and with special connections and a vacuum tank the work is rendered easy and done quickly.

***Other electric equipments** for the shop are; electric vulcanizers, portable electric drills, portable grinding and polishing lathes.

Air hose for compressed air garage work must be heavy and comes in 6 ply. Size ¼ inch (inside measurement).

For hand and portable pumps, 3/16 inch, 3 ply; 3/16, 5 ply.

**How to Determine Speed and Size Pulley to Use for Driving Air Compressors.

ne speeds at which air compressors should op- s is of importance and is determined by the of pulleys. It should be remembered that larger the driving pulley, the faster the compressor, (having a given size pulley) will be driven vice versa. We give here the method of deining the pulley sizes and speeds under differconditions:

Then compressor is driven direct from electric or a 3 in. pulley should be used on the motor keep the pulley on the compressor as small as ible. To determine the size of compressor pulmultiply the speed of the motor by the diameof motor pulley and divide the result by the ber of revolutions of the compressor:

xample—what size compressor pulley is reed to drive an air compressor at 340 r. p. m. ct from an electric motor having a 3 inch puland running at 1700 r. p. m. 1700×3=5100 40=15 inch pulley on compressor.

Then it is desired to drive a compressor from otor by means of a countershaft; to ascertain the of countershaft pulleys, multiply the speed of the tor by the diameter of its pulley and divide by desired speed of the countershaft, this gives size of the driven pulley on the countershaft. n multiply the recommended speed of the comssor by the diameter of its pulley and divide the ult by the speed of the countershaft for the size its driving pulley.

Example—It is desired to drive an air compressor, having a 9 inch pulley, at 350 r. p. m. by a motor having a 3 in. pulley and a speed of 1700 r. p. m. The compressor cannot be driven direct from the motor and a countershaft must be used. What size pulleys must the countershaft have?

1700×3=5100÷425 (speed of countershaft) = 12 in. Size of driving pulley. 350×9=3150 ÷425 (speed of countershaft) = 7.4 in. The nearest commercial pulley is 8 in. Therefore an 8 in. driving pulley is used on countershaft.

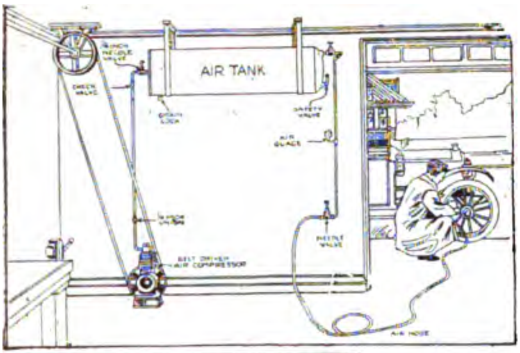
When countershaft runs the same speed as compressor, then the pulley on compressor and drive pulley on countershaft, must be the **same** diameter, irrespective of what that diameter is, any where from 3 inches to 3 feet.

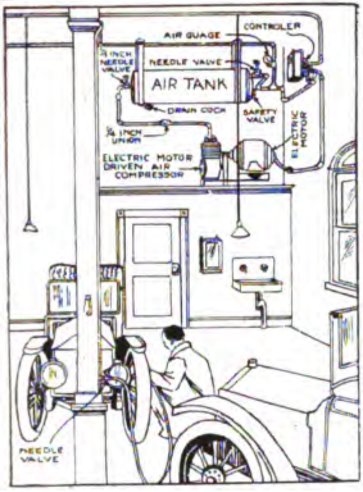
When an air compressor is driven from a line shaft without a countershaft and the size of driving pulley is required, multiply the speed of the compressor by the diameter of its pulley and divide by the speed of the line shaft.

Example—an air compressor having a 9 in. pulley is to be driven at 350 r. p. m. from a line of shafting having a speed of 450 r. p. m. What size pulley must be used on the line shaft? 350× 9=3150÷450=7 in. Size of driving pulley on line shaft. (see also page 617.)

RT NO. 237-A—Various Uses of Air Compressors. How to Determine Size of Pulley to Use for Driving Air Compressors. Many Uses of Electric Current in Shop and Garage.

e Brunner Mfg. Co., Utica, N. Y. for catalog of portable and other types of Air Compressors. **See page 617.





Belt driven compressor shown above.

Electric motor driven below.

**Power Air Compressors For Shop Use.

Belt Driven Garage Outfit No. 2.

For garages housing 15 to 20 cars and for vulcanizing shops.

1—No. 100 belt driven compressor, 8" T. & L. Pulleys*	$ 18.00
1—20 Gal. 14" x 30" Galvanized Air Tank	11.00
1—Model "B" Air Gauge	2.00
1—No. 75 Vertical Check Valve	1.25
1—No. 72 Safety Valve for Air Tank	2.00
1—No. 83—¼" Needle Valve	1.25
1—No. 83—⅜" Needle Valve	1.25
1—No. 82—⅜" Needle Valve with Swivel	1.50
1—Tire connection and 25' hose	5.00
	$ 43.25

Electric Motor Driven Garage Outfit No. 7.

For garages housing 20 to 25 cars and for vulcanizing shops.

1—No. 41 Motor Driven Compressor, 110 or 220 V. 60 Cy. A. C.	$ 95.00
1—24 Gal. 14" x 36" Galvanized Air Tank	12.00
1—Model "B" Air Gauge	2.00
1—No. 75 Vertical Check Valve	1.25
1—No. 72 Safety Calve for Air Tank	2.00
1—No. 83—¼" Needle Valve	1.25
1—No. 83—⅜" Needle Valve	1.25
1—⅜" Needle Valve with Swivel Connection	1.50
1—Tire connection and 25' hose	5.00
	$121.25

Size Tank To Use.

Tanks at pressure given, will inflate 35x4½ tires to 85 lbs. as shown in table.

Tank	Size	200 lbs.	180 lbs.	160 lbs.	140 lbs.
20 gal.	14x30	4 Tires	3 Tires	2 Tires	1½ Tires
32 "	16x36	6 "	5 "	4 "	3 "
40 "	16x48	9 "	8 "	6 "	4 "
50 "	16x60	12 "	10 "	8 "	6 "
65 "	8x60	15 "	13 "	10 "	8 "
80 "	18x72	19 "	17 "	13 "	10 "

After inflating tires of this size, each will have from 89 to 90 lbs. left with which to inflate several smaller tires.

Construction of a Fabric Tire.

The carcass, which is the strength of the tire, is built up by placing several layers (4 to 7) **of closely** woven cotton fabric on a mandrel or core shaped like the inside of tire. The carcass is dependent upon the tread, cushion and breaker for protection.

Cotton fabric is used because it is flexible, easily permeated with rubber and best resists heat. **If too many layers of fabric were used,** it would thicken the carcass, causing it to be stiff, less flexible and inside plies would break easily and heat would be difficult to expel. Heat has a tendency to loosen the "frictioning" between the fabric plies.

The tire assembly is as follows: (1) **One layer or ply of fabric** is placed over core.

(2) **Bead** is formed by placing the lower edge of fabric around the bead form; hard rubber is **used** to form bead of a clincher tire and small wires for straight side tires.

(3) **Other layers or plies of fabric are placed, one over the other,** but before doing so, rubber is **infused** by pressure, into and between each layer or ply of fabric which impregnates the fabric thoroughly; this is called "**frictioning.**" (4) **A cushion of ⅛" soft gum rubber** is placed over the fabric carcass.

(5) **Breaker-strip** is then placed over the cushion. It is made of coarse loose woven fabric and it serves to ward off attacks of sharp objects that may penetrate the tread. When a tire wears through the tread, the "breaker" is exposed.

(6) **A chaffing strip,** consisting of a strip of fabric about 2" wide, is applied to edge of and above bead.

(7) **Then the side walls,** made of thin tough rubber (made thin to expel heat) is applied.

(8) **The tread,** made of thick tough rubber is applied last.

(9) **Then tire on forming core, is placed in an iron mold** divided into halves (see fig. 28). The part U, of this mold is placed over the part L, covering tire and fastened.

(10) **The mold with tire is then placed in a cylindrical tank or kettle,** or hydraulic press vulcanizer and open cured.***

(11) **Live steam is turned into this tank at a pressure of 50 to 60 lbs.,** which corresponds to about 300° F. This tank holds from 25 to 30 tires.

(12) **After curing,** tire is placed in storage to "after cure."

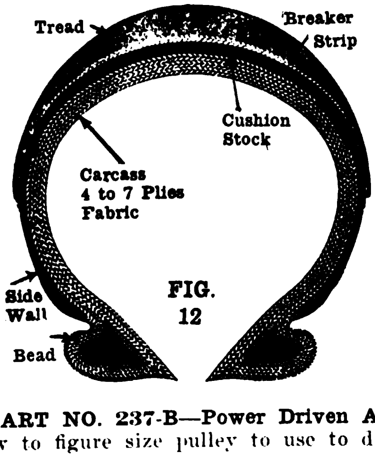
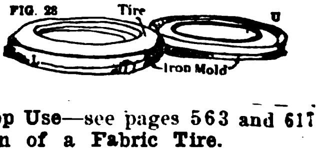


FIG. 12

FIG. 28



HART NO. 237-B—Power Driven Air Compressor Outfits for Shop Use—see pages 563 and 617 ow to figure size pulley to use to drive compressor. **Construction of a Fabric Tire.**

*One tight and one loose pulley. ****Above Air Compressor Outfits mfgd. by Brunner Mfg. Co.,** Utica., N. Y write for catalogue. Prices quoted above not guaranteed. Subject to market conditions.

*****Cured,** means vulcanizing; **open cured,** is process where live steam comes in contact with the raw rubber; **dr cure,** is where steam is not in direct contact; **uncured,** is raw unvulcanized rubber.

INSTRUCTION No. 42.

TIRE REPAIRING: Construction. Tire Troubles; cause and remedy. Inner Tube Troubles; cause and remedy. Care of Tires. Vulcanizing Methods. Address of Tire Manufacturers.

Construction of Pneumatic Tires

There are two kinds of pneumatic tire constructions: the "fabric," and the "cord" construction.

In the fabric construction the carcass is made of closely woven, and **interwoven** cotton fabric, see page 564, fig. 12.

In the cord construction, the carcass is made of loosely woven cords and **not interwoven,** see page 559.

The fabric carcass type of tire can be constructed by two methods; the "full-molded" method and the "wrapped" method.

The full molded method is constructed as explained on page 564. It is built up on an iron core or mandrel and is then placed in a mold (fig. 28), which in turn is placed in a hydraulic press vulcanizer, the object of the press being to close the halves, L and U of the molds tightly. With a full molded type tire, the entire construction is **cured or vulcanized complete at one operation.**

With the wrapped tread method, the fabric carcass, side walls, cushion and breaker-strip are formed or built up in the same manner as a molded tire, but is semi-cured (half-cured) in this mold. After this semi-cure operation it is **removed** from the molds (fig. 28), and the part where tread goes is buffed off and cemented with several coats of high grade vulcanizing cement. A semi-cured tread is then treated with several coats of vulcanizing cement and allowed to dry, after which tread is applied to carcass and rolled down under pressure to remove all air.

An air bag is then placed inside of the tire and entire tire is **wrapped tightly with canvas cloth strips** about 2 in. wide, then instead of putting back in the mold (fig. 28), where it was semi-cured, it is placed in a horizontal vulcanizer (large kettle) and the final cure (vulcanize) with live steam is given, after which the tire is left standing until cooled and then canvas strips are removed and tire is then laid away for a few weeks to "after cure."

A wrapped tread tire can always be distinguished by the slightly roughened surface, which is the impression from the cloth wrapping.

The advantage of the wrapped tread construction is the possibility of detecting if there are defects in the tire, as pinches or buckles, which can be determined before tread is applied, which enables the manufacturer to turn out a perfect tire. This type of tire is more expensive to manufacture.

The rubber used in making the tread and cushion stock of a tire consists of a gummy substance obtained from the milky juice of certain tropical trees, mixed with sulphur to tend to harden it and give it strength. When heated, it changes from a sticky mass resembling chewing gum, to the elastic form in which we see it in a completed tire.

The best rubber is called Para, which comes from the city of Para, near the mouth of the Amazon river. Other good rubber comes from Africa, India, Ceylon, So. America.

The white dust often seen on rubber goods is called "bloom"* and is due to the sulphur in the rubber not chemically combined with it. Old tires in stock a long time accumulate considerable bloom and get hard.

**Care of Tires.

Proper inflation. Keep tires inflated to pressure **recommended by the maker. Nothing ruins a tire so quickly as running it so soft that the canvas continually bends. It is almost impossible to over-inflate a tire with a hand pump.**

Running a flat tire, even a short distance, is sure to be costly. Better run on the rim, **very slowly and carefully, if imperatively necessary, and the distance is short.**

Keep grease and oil away from your tires and tubes always. They destroy rubber.

Speedy deflation demands instant **attention. Carry** an extra casing and inner tube.

Don't let weight rest on deflated tires even over **night.**

Equalizing traction: It is important that tires **of the same** diameter be used on the rear **wheels.** Furthermore, special treads and chains should be **used in pairs.** If there **is** a variation in the diameter of the rear tires or in the **traction** of the **wheels. the differential is caused to work whenever the car is in motion. In this way, considerable** power **is lost and the differential parts are unnecessarily worn.**

***Alignment of wheels: It is very important that the wheels** are in **alignment, if out of line, the tire treads** will wear, **in a very short while. As usual** in this **case, the tire manufacturer will not guarantee or rebate, on a tire tread ruined** by **wheels being out of line—see** "alignment of the **wheels,"** chart 279. and index.

Side skidding and rounding corners rapidly will cause rim cutting.

Avoid running **in the street car tracks.** It **is very detrimental to the tires.**

Do not drive in the ruts or bump the side of the tires against the curbing or pavements, and don't start your machine with a **jump.**

If one of your tires sustains a cut to the extent of exposing the fabric, an emergency band or patch should be applied at once.

Keep an odometer record of the mileage of each tire. You will find that you are getting better mileage than you would otherwise imagine.

Keep rims in good order, straight and true. Rust is destructive. Paint preserves.

***Wheels running over a fraction of an inch out of alignment** cause a grinding wear on the rubber Front wheels suffer most

**A useful and valuable booklet "Care and Repair of Tires," issued by The Firestone Tire Co., Akron, Ohio, will be sent free on request, by writing this firm. A good deal of beneficial information is contained therein, also write B. F. Goodrich Co., Akron, Ohio.

The rims, if rusted, should be thoroughly cleaned and sandpapered, then painted with liquid graphite (common stove polish will answer). Also apply to bead of tire.

Inner tubes. Carry them in the coolest part of the car away from oil cans, and tools. The best protection, is a soft bag, well dusted with soapstone, in which the carefully folded tubes are put. See chart 238—**how to fold an inner tube.**

Unless some pressure is retained however, the tube will have a tendency to crack when again inflated, if left folded for a long time.

Before "stabling" your car at night examine your tires and remove small pieces of glass, little nails, etc., that may have become lodged in the rubber. Next day they are apt to work their way through and cause a puncture.

Spare tires should be kept in a place where they are not subjected to light, heat, or rapid changes in temperature.

Nothing will wear a tire faster than sudden locking of the rear wheels and turning corners at considerable speed. Use your brakes with judgment and turn corners slowly.

Never allow a tire to wear until the canvas fabric becomes injured, because the wall of the tire is apt to become too thin to prevent the pressure of the inner tube from bursting through the weak portion. Remember that the strength of the tire is in the fabric. The rubber is merely a binder which unites the various layers of fabric and forms a covering over the whole.

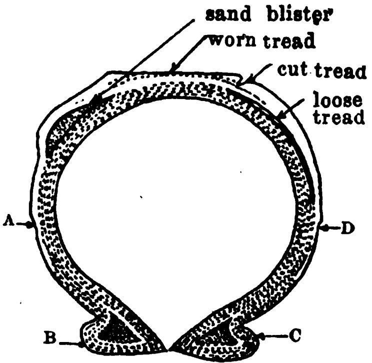
Tire Troubles; Causes and Remedy.

Some of the tire troubles are; stone-bruises, loose treads, sand-blisters, worn-treads, chaffed tires, rim-cuts, punctures, cuts clear through carcass, blow-outs.

Stone bruises are caused by tire striking a stone at a high rate of speed resulting in one are all layers of fabric breaking, yet tread may not even be cut. Inner tube works into this break and a blow-out, per fig. 4, page 567, results. Tires have been known to blow-out while standing in the garage due to stone bruise. **Examine tires when off rim** and feel of the fabric, inch by inch for a weak spot, or if break is clear through, you can see it, per fig. 5.

A temporary repair can be made by using "inner" and "outer" shoes, per page 568, but it is advisable to repair as per page 575, as a blow-out may occur even with this "inner shoe" covering the weak spot.

The cord tire is not subject to stone bruises because the cords are not interwoven, or cross woven like a fabric tire and instead of breaking, they give.



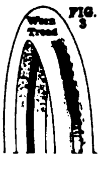
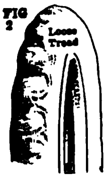


FIG. 3

FIG 2



Sand-blisters are caused by a small hole or cut in tread through which sand and dirt work under the tire causing it to pucker up and will result in a loose tread if not closed up. The hole through which the sand worked into and under tread may be several inches away. **Close it up** with a plastic substance called "tire dough" **or vulcanize it.** See page 570; "sand-blister repair."

Loose treads result from running a tire not properly inflated, or from moisture getting under tread through a cut in the tread, or from a defect in the tire where the rub- compound is poor and does not adhere.

Loose treads can be repaired unless the tread is loose about 1/3 of the way, in this instance a new tread must be applied—providing the fabric carcass is not cut—if so, repair it first—and providing layers or plies of fabric in the carcass are solid and are not separated.

The molded type of tire is more subject to loose treads than the wrapped tread construction.

Worn treads in center, or slightly to the side of tire, usually result from driving in street car tracks, wheels being out of line (usually on the front), due to steering knuckles bent or steering apparatus out of order. See page 683.

Chaffed tires, usually worn on the side, result from driving close to curbstones, in street car tracks, ruts, etc. This permits water to rot the fabric. **Repair** by rebuilding the side walls and vulcanize.

Rim cuts are due to running tire flat after a puncture, or running on the rim which damages the curve in rim and which cuts the tire at the rim just above the bead. Improper inflation is also a common cause, this permits the edge of the rim to cut the bead when deflated tire receives a heavy jar. **Rim cuts can be repaired** if cut in only two or three short places, but if cut at sections all around tire, then it cannot be repaired.

Punctures through tread and carcass, if small, will not cause damage to carcass but the tread should be closed by vulcanizing with the small vulcanizer while tire is inflated on car, or some kind of plastic material as "tire dough" stuffed into it to keep water and sand out.

Where tires are cut through the carcass, this can be repaired if cut does not extend too long and the plies of fabric are not separated. It is repaired the same as a blow-out repair, page 575.

Retreading.

Retreading: It is no easy matter to form a correct judgment about any tire with regard to retreading. In some instances a tire case may appear to be sound and yet prove to have stone bruises in the carcass on inside examination, or the layers of fabric may be separated from each other. On the other hand, there are undoubtedly covers condemned because of local damages, which properly examined, would prove worthy of retreading.

The age of the tire and condition of fabric and cost of retread will determine if worth while to retread. The strength of the tire is in the carcass. The rubber tread is merely a protection.

Therefore the condition of the carcass must be determined when deciding as to retreading. There are three conditions to note; (1)—is the carcass badly cut in several places—if so, don't retread or repair; (2)—are all the layers of fabric of carcass together and not separated; sometimes these fabric layers separate and pucker up due to improper adhesion in manufacture, or water getting under tread and into the carcass; (3)—is tire rim cut badly

Blow-Outs.

Greatest tire trouble—blow outs. A blow out is simply a hole blown through the carcass or fabric. **There are two classes of blow outs;** those occurring near the rim and those in the tread or on the side.

Fig. 4—When a blow out occurs it always leaves a weak spot.

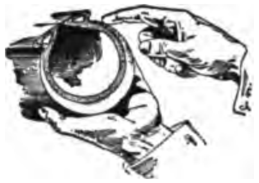


Fig. 5—The tire is made thin here for a purpose.

We will designate the first mentioned as a "**rim blow out,**" and the latter as a "**tread blow out.**" Wherever a blow out occurs, that spot always remains weak, because the fabric can never be joined again, but can be repaired, see page 566.

Cause of rim blow outs: A tire is made **thin** at the point shown in the illustration (fig. 5), near the rim, for a purpose. Very nearly all the "bend" and "give" is at this point. If it was made thick and heavy, it would break; therefore, it must be thin and flexible.

If you were to take a wire and bend it quick and often it would get hot and break—same with this bending point of the tire near the bead—especially if the tire is not properly inflated.

Cause of inside breaks in fabric are due to stone-bruises and running tire improperly inflated—see page 566.

If you were to take a deck of cards and bend them back and forth, it would be noticed that the bottom cards would receive most of the sawing strain—just so with the several plies of fabric when tire is not properly inflated.

Therefore keep tire inflated and many of the tire troubles will be avoided.

A tire may **look** sufficiently inflated and yet have only 40 pounds of air in it, when it should have seventy. No amount of kicking, feeling or looking will tell; the only sure way to tell is to have a reliable air gauge—see fig. 14, page 568.

Cause of tread blow outs are due to cuts on tread and stone-bruises. Cuts and jabs ou the tread of tires permit dampness, oil or dust to get between the rubber and the fabric, which soon rots and weakens it.

Inasmuch as the fabric must sustain the air pressure, a weak place in the fabric **is enlarged by the pressure** and a blow out is the result—and once a blow out occurs, it can never be repaired so that it will be strong as it was at first.

Therefore repair cuts in the tread and examine tires for internal fabric cuts caused by **stone-bruises,** when tire is off wheel.

External cuts in the tread can be vulcanized while inflated and on wheel—with the small vulcanizer shown on pages 570, 573.

A temporary repair of a blow out or an internal fabric cut, or weak places in the carcass can be **temporarily** protected by inserting an **inner shoe** between inner tube and carcass and an **outer-shoe** over the tread, per fig. 11 and 9, page 568. The defect should be repaired as **soon as possible** however, as a cut in the fabric will soon work larger and cause a blow out from rim to rim.

***How to get additional mileage or service out of old tires:** Very near every motorist has one or more old tires which is of no use. Many will be interested in knowing that these old tires can be made serviceable again by placing inner shoes inside of the tire, covering the weak spots or holes and then placing reliners inside of the tire over those reinforced places (see fig. 17, page 568).

**Inner Tube Repairs—Causes of Trouble.

Punctures may result from a puncture through tire from outside, or it may result from rough places inside of case, as soapstone balls, etc.—(see page 569), or from tube being pinched.

Tube pinching. Referring to the most common causes of damage to inner tubes, attention is called to the manner in which many tubes are pinched beneath the bead of tire or beneath the staybolts—(see fig. 1, page 568, also "stone-bruises," page 566).

The valve may leak. It sometimes happens that a tire becomes deflated because of a leaking valve, and the condition may easily be supposed to be due to a puncture. **If no visible sign that the tire has been penetrated is discovered,** put a few drops of water in the valve stem. Bubbles will indicate a leak, or the valve can be tested as shown in fig. 3, page 568.

If such is the case, the valve parts should be tightened with the notched cap (B) of the valve stem inserted in the valve and used as a wrench. (See fig. 2, page 568).

If this does not remedy the trouble, entire new valve parts (A) page 550 should be put in place. Every repair kit is supplied with them and they should be kept in the kit constantly, as well as caps (B).

Method of Repairing Inner Tube.

In this case the inner tube is supposed to be punctured, but the casing practically uninjured, as in the case of puncture by a nail or tack.

First of all, satisfy yourself that the tack or nail is not sticking in the casing, for if it is, your repaired tube will be punctured again before you have gone 1,000 feet. Having done this, the inner tube may be removed (wholly or in part, as may be necessary) and either repaired or replaced.

---

*Reliners should never be placed in new tires. They are detrimental to tire and tube and are used only for old tires ready to throw away or where additional mileage is desired. **See page 574 for prices usually charged for inner tube repair work.

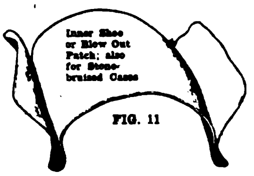
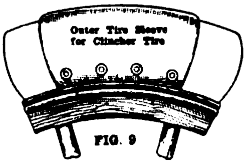
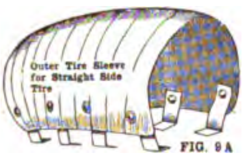
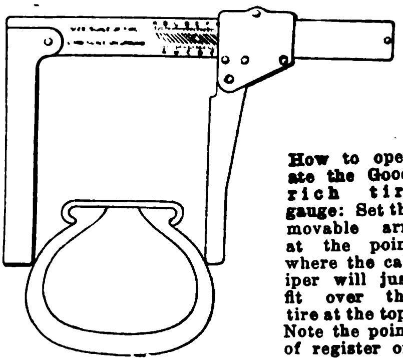


Fig. 11—Inner shoe, to go on inside of tire to protect fabric cuts, breaks or weak places due to small blow outs or stone-bruises or rough spots and also a protection to rim cuts. Made of 3-ply fabric with wings, to go under the rim.





Figs. 9, 9A—Outer shoe, to be placed temporarily on outside of tire when cut or damaged until vulcanized. Note lower part fits under rim for clincher, and under tire for straight side. Call for this type.



How to operate the Goodrich tire gauge: Set the movable arm at the point where the caliper will just fit over the tire at the top. Note the point of register on "size scale of tire" and move the arm to the corresponding mark on "load scale on ground."

Now test the tire at the bottom where the load rests on it. If the caliper just touches the sides the tire is inflated properly. If tire is too much flattened to permit the caliper to slip over it, inflate the tire until tire under load is just as wide as space between arms. Above shows tire underinflated.

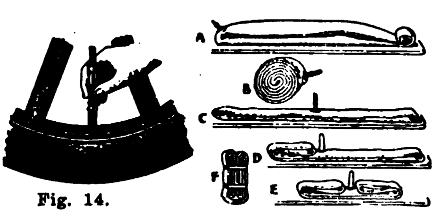


Fig. 14.

Fig. 14: Twitchell air gage is placed over the valve stem and indicates pounds pressure in tire.

Fig. 7, A to F: To fold an inner tube, remove "inner-valve" per fig. 2, then roll slowly per A and B to exclude air. Then lay flat and fold per C, D, E and F. A flannel bag is suitable for carrying extra tubes in.

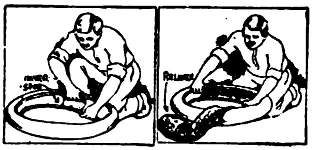


Fig. 16—Insert an inner shoe for small blowouts or weak places in tires.

Fig. 17—For bad cuts or large blow outs, or when using an old or worn out tire. First insert inner shoes over the holes, then reliner in inside of tire as shown.

Reliners are hard on inner tubes and are not advisable to use in new tires—only for temporary repair of old tires.

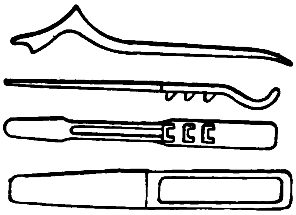


Fig. 12.—A set of tire tools suitable for attaching and detaching "clincher" tires on one-piece rims. In addition to these tools a good heavy hammer and a reliable jack, come in handy as well.

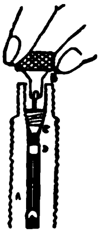


Fig. 2.

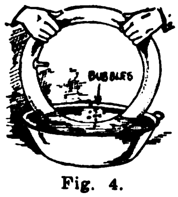


Fig. 4.

Fig. 2—To remove "inner-valve" when tube is to be deflated—use notched end of "valve cap" B.

Fig. 4—To test inner-tube for leak; partially inflate tube and place in pan of water; air bubbles will appear at leak. Mark leaks with indelible pencil. See page 785, fig. 20 for a testing tank for shop.

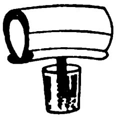


Fig. 3.

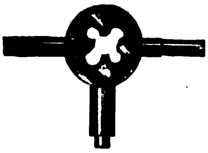


Fig. 5.

***Fig. 3—To test inner-valve for leak; inflate tube; place end of valve, with valve-cap removed, in glass of water—if bubbles appear inner-valve leaks. Put in a new one.**

Fig. 5 — Four-in-one valve tool; die for re-cutting threads for valve cap; tap for inner-valve threads; inner valve remover.

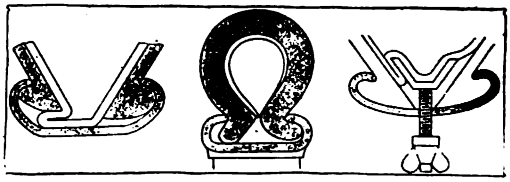


Fig. 1—Showing how the inner-tube may be pinched be-tween the bead and casing; between the two beads, or bead and lug.

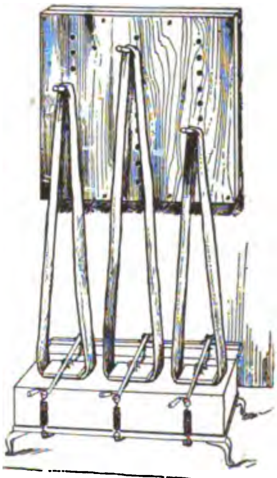


Fig. 21—A rack for vulcanizing different size tubes. This device can be used in connection with the small tube vulcanizers.

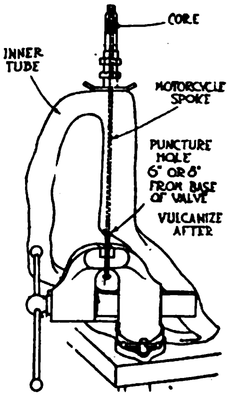


Fig. 20—Sometimes inner-valve core becomes immovable from stem. Diagram explains how to remove.

HART NO. 238—Miscellaneous Tire Repairs and Accessories. Testing Inner Tubes for Leaks. How to Properly Fold an Inner Tube. Tire Air Pressure Gauge. Inner and Outer Shoes.

o test base of valve for leak, submerge valve part of tube in water, with tube partially inflated, per fig. 4.

When on the road it is much simpler to put in a new tube; and it is best to have always at hand three spare tubes—one for the forward and two for the rear tires. An inner tube properly vulcanized is as good as new, but it is much easier to make the repair at home. **Do not carry these tubes in the tool box** where they are liable to be bruised or otherwise injured.

There are two methods of repairing an inner tube; by **cemeting** a patch over the puncture and by **vulcanizing**. The cement patch does not hold and will leak in time; therefore, the vulcanizing of the tube, as shown in charts 239 and 240, will make a permanent repair. The best plan would be to insert a new tube and vulcanize the damaged one later.

Cementing a Patch.

If a cement patch is necessary, owing to the absence of a vulcanizer, then proceed as follows: **Select a patch of the right size**; that is, large enough to extend three-fourths of an inch or an inch beyond the puncture in each direction. Wipe off every trace of moisture or bloom and roughen with emery cloth the surfaces to be joined. Apply two coats of cement to the tube surface and to the patch, removing with the fingers all superflous cement; the less of it there is, the quicker the repair.

Allow the cement to dry until it adheres strongly to the fingers (five minutes at least will be needed), then, and not until then, apply the patch: compress strongly and look carefully to see that the edges of the patch do not loosen.

Before putting back the tire, assure yourself that the cause of the puncture is removed, as a nail or tack or rough spot inside of casing, else tube will puncture again.

Note.—Never try to join two surfaces while they are still damp, for rubber cement joints are of no value unless everything is dry. Never apply friction fabric to an inner tube, but always a patch of pure caoutchouc. Friction fabric is not air-tight.

Even though a sound tube has been inserted on the road, the punctured tube should be mended promptly to be ready for another emergency. There is scarcely a limit to the number of repairs a tube will bear, but patches applied with cement cannot safely be considered permanent repairs. **It is a paying investment to make vulcanized repairs** as opportunities present themselves.

When a patch becomes loose. It will sometimes happen that a tire will become partially or even entirely deflated without apparent cause—that is, without any nail or other puncturing instrument being visible. If you have had experience with occurrences of the kind, you will immediately suspect a loosened patch and proceed to verify your suspicions. Partly inflate the tire and your ear will tell you whereabouts the leak is. Only remove as much of the casing as will enable you to conveniently attack the job. You will very likely find that, although the air has burrowed a small channel between the patch and the tube in one place, other portions of the patch are holding on tenaciously. Why an inner tube patch does not stick all over alike, is what no one ever could understand.

A drop of gasoline applied with care does wonders in persuading the patch to peel off, and afterward in cleaning the surface of the tube; but do not apply the solution until you have well roughened the place with sandpaper. Put the old patch away for future use, and apply a fresh patch, two coats of solution, spread on thinly, and well rubbed in, especially the first (you cannot rub the second coat hard, or the lot peels off); squeeze the patch and tube together as hard as possible with finger and thumb, beginning in the center of the patch and working out to the edges. You may hold a block of wood under the tube and beat the patch with a hammer if preferred, but go gently. One motorist belabors his patches unmercifully and, says they never come off. Judicious beating does no harm, and screwing up in the vise between two pieces of wood, and leaving all night also works wonders.

Inner Tube Pointers.

How to carry extra inner tubes. Deflate tube and fold, as shown in fig. 7, chart 238, powder the tube with a generous amount of talcum powder, then wrap in a piece of canton flannel or cheesecloth and pack in a small wood box with a sliding top; this will protect tube indefinitely.

If the car is equipped with smaller tires on the front wheels than on the rear wheels, carry an extra tube for each size.

The cross sections of inner tubes are made a little smaller than the normal air space inside of the cases. It is not, therefore, advisable to use a 4½ inch tube in a 4 inch case. This usually wrinkles and creases the rubber, with bad results. Do not use a 4 inch tube in a 4½ inch case for any length of time. When this is done the rubber is required to stretch too much and the effect of heat and action due to displacement of air in the tire quickly uses up the nerve and life of the tube.

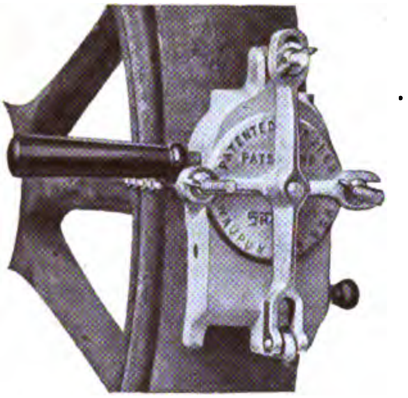
Lubrication is most important to the conservation of the tube, but it is a matter that is given least attention. Practically all tire manufacturers treat the inside of cases with a white solution to prevent tubes from *sticking to the casing, and to reduce the frictional wear—a good lubricant, however, should also be used.

Some owners neglect dusting soapstone inside of the case when changing a tube, others use the soapstone so sparingly that it does but little, if any, good, or they may use so much that it does more harm than good. If a quantity of it be dumped into the case it will collect at one point, and during the hot weather will heat up to such an extent as to burn the rubber of the tube, making it very thin, brittle and lifeless; this can be recognized by the honeycombed appearance. **Soapstone** is the lubricant most used for tires and it is quite satisfactory, but not lasting; therefore a fresh supply should be put into the tires at least two or three times during the season. **Powdered mica** has proven a more durable lubricant than soapstone and quite as effective as graphite, as well as more pleasant to handle. The lubricant should be applied with a soft rag and rubbed into the pores of the tube, also on the fabric all around the case.

Life of an inner tube—if good rubber, should last for two years. As tube grows older the rubber becomes hard and porous and finally reaches the "past repair" stage, which is noticeable by constant slow leaks. New tubes are then advisable.

*__A gray inner tube__ is not colored. The best gray tubes use pure Para gum with sulphur, to give it strength. This sulphur causes a "bloom" or white gray dust which gives it the color.

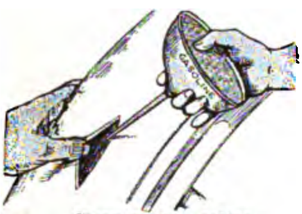
A red inner tube uses a dye to give it color and instead of sulphur, antimony is used, which will stand a greater amount of heat. Heat causes rubber to harden and crack. Gray tubes stick to cases, red tubes will not stick. Therefore, the advantage of a good red tube is in these two points.



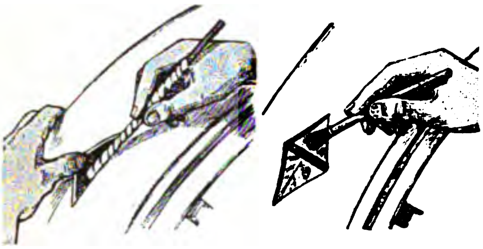
The tourists gasoline or alcohol vulcanizer, vulcanizing the outer casing.

To Vulcanize Tire.

To prepare casing and patch—thoroughly cleanse the cut or tear by using sand paper or a pocket knife and wash same perfectly clean with a rag, using gasoline. Cleanse a layer of repair gum with gasoline, insert it in the cut and trim it flush with the casing. If the injury is void of material, then build up even with casing by cleaning each layer of repair gum with gasoline and firmly pressing into place.



Clean with gasoline.



Get all dirt out, then cut old rubber away and give hole another cleaning.

To apply vulcanizer: Firmly clamp the center of the vulcanizer directly over the prepared patch, using care to have the patch centrally located against the face of the vulcanizer as illustrated. Before applying the vulcanizer, the face of same may be dusted with soapstone or talcum powder or a cake of ordinary soap can be rubbed against it to prevent repair gum from sticking.

To Vulcanize Inner Tube.

Preparation of tube and patch—to repair a punctured tube. Clean the spot around the puncture about two inches in diameter with emery paper, then wash off clean with gasoline. Cut sufficient repair rubber to cover the puncture and dampen the surface of the rubber to be applied to tube with gasoline, allowing it to dry thoroughly. Then apply the repair rubber to the tube directly over the puncture, as illustrated in fig. 1.

Figure One

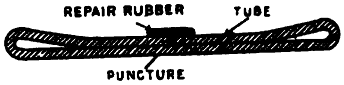
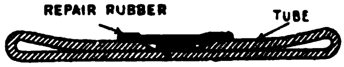


Figure Two



To repair a rent, pinched or torn tube—shear off damaged part to a beveled edge and follow cleaning and washing instructions as above. A piece of repair rubber the exact size and shape of the hole must be placed in position and another piece of repair rubber larger over all than the hole must be placed on the damaged part; as illustrated in fig. 2.

Care must be taken that the tube is thoroughly cleaned with emery paper and gasoline; and that the surface of the rubber applied to the tube is washed with gasoline and allowed to dry.

To apply vulcanizer—clamp vulcanizer directly over the prepared tube and fasten securely and uniformly with the thumb screws, being careful to have the patch centralized beneath the vulcanizer, as illustrated in fig. 3.

Operation of tourist's vulcanizer: After preparing tube as instructed, attach vulcanizer as shown. Stand vulcanizer on bench, running-board, or floor. Remove the cylindrial lamp, and pour the gasoline or alcohol on it from the measure which is furnished. Insert lamp into vulcanizer and light it. After lamp goes out, which will be in about ten minutes let the vulcanizer cool a few minutes and the repair is done.

When vulcanizing a casing clamp the vulcanizer in place with the chain furnished with it. Heat the vulcanizer with the lamp as above. There is no exposed blaze and no chance to spill burning fuel so that it is perfectly safe to vulcanize a tire while inflated on the wheel.

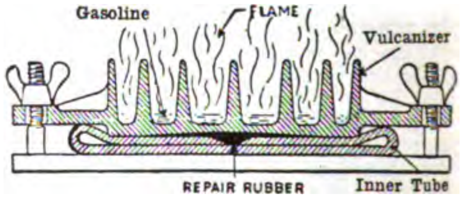


Fig. 3—Showing inner tube being vulcanized and how the gasoline or alcohol heats the vulcanizer on another type of gasoline vulcanizer.

*Repairing Sand Blisters.

(1) Cut half way around the blister, cutting through the rubber to canvas (C) and leave rubber attached on the side nearest tread of tire. Turn back the flap (F) thus formed and remove all dirt; then clean and cement as directed for casing cuts per above.

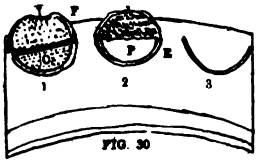


FIG. 30

(2) Cut a strip of Para rubber as wide as the rubber on the tire is thick and stick on edge of cut (E). Then cut a thin sheet of Para the exact size of the canvas and roll back in place and stick it down tightly (P).

(3) Shows repair after vulcanizing. Be sure to vulcanize hole where dirt entered and caused the blister, it may be a foot away—vulcanize as per instructions for small cuts,—see also pages 570, 573.

CHART NO. 239—A Portable Vulcanizer for Vulcanizing Small Cuts on Tires and Inner Tubes.

A tire pump is an excellent bellows for blowing dirt out of a cut for a repair to be vulcanized. **A sheet of waxed paper** should be placed between vulcanizer and tire to prevent sticking to hot iron.

***To repair a section of a tire where tread is loose:** Cut through the tread, clean under side of tread and canvas thoroughly. Apply two or three coats of cement; when dry replace tread, wrap with tape, per fig. 25, page 575 (this is the wrapped method of vulcanizing)—then cure with inside and outside heaters as instructed for blowts, figs. 25, 26, page 575.

Valve Spreaders.

It is essential that tubes be equipped with valves having the correct type of spreader. See figs. 3, 4 and 6, (L), chart 235. Fig. 4 and 6 would interchange because they have angular shaped sides whereas fig. 3, chart 235 and fig. 1, chart 236-AA have curved sides. Most companies have in the past furnished tubes with especially equipped valves for clincher cases, another type for Q. D. clincher cases, and still another type for straight-side cases. The clincher valve spreader will not properly lock the Q. D. clincher beads on a Q. D. clincher rim, nor the straight-side type of tire on a straight-side rim. The valve equipped with a straight-side spreader will lock the beads on a clincher rim or a Q. D. clincher rim, but on account of difference in width and shape may damage fabric of the case.

The purpose of a spreader is to keep inner tube from being pinched at the stem hole in the rim, also to act as a protection in case dust cap is screwed down too tight, which is very often the case and inner tube is partly pulled or pinched in rim hole.

Spreaders are not absolutely necessary, but as stated above, they greatly lessen the chances of tubes "going bad" around the valve stem, before the rest of the tube has given all the service that has been built into it.

The difference in the spreaders is necessary, due to the difference in space between the beads as they set on the rim.

Repair of Tires.

Temporary tube repairs can be made by the use of cemented or self-curing patches which are easily applied. However, as patches are unreliable, owing to the fact that they often come off when the tire heats from running, it is much better to make permanent repairs in the first place by vulcanizing.

A small vulcanizer per page 570 and 572 can be used for vulcanizing inner tubes, which is a very simple operation. The tube is cleaned around the puncture and coated with vulcanizing cement. Then a piece of raw rubber, the same as that from which tires are made, is placed over the puncture. The vulcanizer is applied as shown in the illustrations, chart 239, and heat is applied for about fifteen minutes, —dependent on the kind of vulcanizer that is used, and the thickness of the rubber being vulcanized. (see also page 572).

For small cuts, sand blisters, etc. on tires, this vulcanizer will also answer, but for blow-outs and large cuts in tires a larger vulcanizer is necessary, see pages 574, 610.

By giving cuts on casings a little attention now and then, tire mileage can easily be doubled or trebled. Small cuts, neglected, admit dirt and water to rot in the fabric until a blowout occurs that ruins both tube and casing. The only sure remedy is vulcanization. See pages 570 and 573 for repairing cuts in casings. This can be done while tire is on wheel inflated.

What is Vulcanization?

It is the process of cooking or curing raw Para gum. Exactly as in baking a loaf of bread, the best results can only be obtained when the proper amount of heat is used.

The temperature ranges form 250 to 300°; about 265° being considered best.

It requires 15 to 20 minutes to vulcanize a layer of Para $\frac{1}{16}$" thick at 265° temperature and 5 additional minutes for each additional $\frac{1}{16}$".

It is immaterial whether vulcanizer be heated by electricity, gas, gasoline or steam. The idea is to keep the vulcanizing surface at a steady and proper degree of heat. **See page 574 and 610 for vulcanizing outfits, tire repair tools, etc.**

Tire Paint.

Tire paint for painting the inside and outside of tires is mixed as follows to make 1 gallon: Mix 1 quart of gasoline and 5 lbs. of whitening, stirring until thoroughly mixed. Add 1 quart of No. 1043 Firestone cold patch cement (or any other cold patch cement) gradually and stir until mixed.

The solution is applied with a brush and leaves a white surface which will not crack due to the elasticity of the cement.

*Motorist's and Shop Vulcanizers.

There are several standard types of motorists' vulcanizers available. They are designed with a view to supplying machines that are adapted to the most convenient sources of heat. On the road, gasoline is always available, therefore for tube work and small casing repairs, a gasoline heated vulcanizer is handiest. Where there are electric lights, they naturally suggest the cleanest and handiest heat. Motorists who have city lighting current in their garages prefer the electric vulcanizer on account of its convenience and large capacity. Most of the work is done at home and an electric vulcanizer, which has its heat controlled automatically and maintained as long as desired (an essential feature), has the advantage that by leaving it on a tire as long as is necessary, the thickest tread repair can be cured clear through as well as a superficial repair. Successive repairs can be made without loss of time as vulcanizer can be moved from one to another.

The charts following will clearly explain the method of tire repairing. It is the writer's intention to deal with the vulcanizing subject only in an elementary way. To those interested in the tire repair business I would advise writing to C. A. Shaler Co., 22 Jefferson St., Waupun, Wis., for a copy of their very complete book, **"How to Open a Tire Repair Shop."** and **"Care and Repair of Tires."** Also Williams Fdry. & Machine Co., Akron, O.

Addresses of Tire Manufacturers.

Write for catalogues, you will gain much information. Amazon Rubber Co., Akron, Ohio. Woodworth Mfg. Corp'n., Niagara Falls, New York. Diamond Rubber Co., Akron, Ohio. Federal Rubber Mfg. Co., Milwaukee, Wis. Fisk Rubber Co., Chicopee Falls, Mass. B. F. Goodrich Co., Akron, Ohio. Goodyear Tire and Rubber Co., Akron, Ohio. Hood Tire Co., Watertown, Mass. Kelly-Springfield Tire Co., 229 W. 57th St., New York, N. Y. Koochook Rubber Co., Kokomo, Indiana. Lee Tire & Rubber Co., Conshokochen, Pa. Michelin Tire Co., Milltown, New Jersey. Mogul Tire Co., Granite Bldg., St. Louis, Missouri. Pennsylvania Rubber Co., Jeannette, Pa. Republic Rubber Co., Youngstown, Ohio. Rutherford Rubber Co., Rutherford, New Jersey. Firestone Tire and Rubber Co., Akron, Ohio.

---

*See also page 610.

Inner Tube Vulcanizing Repairs.

Inner Tube Punctures.

Clean the tube thoroughly with gasoline and coarse sandpaper—see page 570. Cement the edges of the hole and apply a thin layer of cement. Let the cement dry.

If a small hole, fill even with the surface of the tube with layers of Para rubber cut the size of the hole. Cut a patch of Para one-eighth inch larger than the hole or puncture and apply over same. Then cut another patch ½ inch larger than hole and apply over the first. Cover with waxed paper and apply vulcanizer.

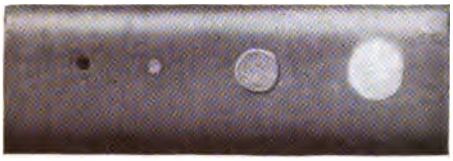


Fig. 1—Repairing tube puncture.

Edges of punctures or small holes should be bevelled with scissors to make a larger uniting surface and provide room for the new material. Repairs of this sort are to be **vulcanized for fifteen or twenty minutes at 265 degrees.**

Inner Tube Cuts and Tears.

Clean as directed, both inside and outside of tube; coat edges of cut and inside and outside of tube with cement and let dry.

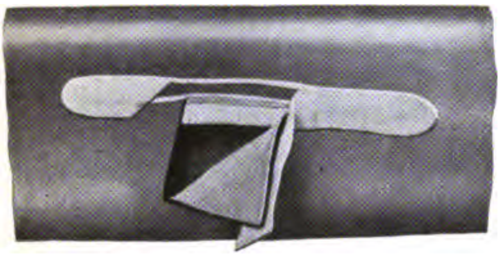


Fig. 2—Repairing slit in tube.

Cut a strip of Para rubber as wide as tube is thick, and stick on edge of cut; cut a strip one-half inch wide, place inside of tube under tear, bring edges of tear together and stick them down to this strip. (The use of semi-cured stock for the inside patch is preferable, as it obviates the use of paper inside the tube). Apply another strip of Para rubber, one-half inch wide on the outside of the tear. **Vulcanize for twenty-five minutes.** Cover the repair with waxed paper before vulcanizing.

Blowouts in Tubes.

When mending large, irregular bursts or blowouts in which a piece of rubber has been blown out of the tube, the best method is to trim down to a clean, solid surface, making the hole somewhat regular in shape. The hole may be filled with layers of Para rubber cut to fit.

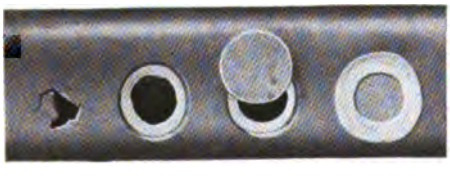


Fig. 3—Repairing tube blowout.

Inner Tube Splices.

It often happens that, when a tube is badly torn, it is easier to cut out a section and replace it with a new piece of tube. In making repairs of this kind be very careful not to alter the original length of the tube.

Clean the outside of one end of the tube for about four inches. Fold back the other end, turning the tube inside out, and clean for the same distance. Apply at least three coats of cement to each end. A repair of this sort requires a considerable amount of cement if no Para rubber is used because the adhesiveness of the joint depends upon the cement alone. A narrow strip of Para between the two tubes will add to the strength of the joint. Butt the open end against the folded end and telescope the latter over it. **Vulcanize in three operations,** the first twenty minutes' duration; the last two, fifteen minutes each. A block should be used underneath tube, to prevent pinching the edges of the tube. Vulcanizer is placed on top.

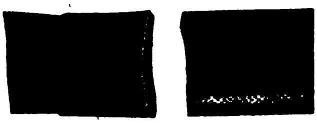


Fig. 4—Splicing an inner tube; showing tube ready to lap.

Fig. 4A—Tube after lapping.

Valve Stem Seat Repair.

Select a good place on the tube, clean a space about four by two and one-half inches and cut a hole about one-fourth inch in diameter. Remove parts from the valve stem and stretch the hole in tube over the base of valve stem. Push the stem clear through into the tube. It is to be kept inside and away from the repair until after vulcanization. Cement entire clean surface around the hole in the usual manner. Cut an oval or diamond-shaped piece of Para about two by three inches, having hole in center to correspond with the hole in the tube. Roll it down on tube so that both holes register. Cover with a layer of blowout canvas of same size and shape. Cover all with another layer of Para rubber one-quarter inch larger all around than the first. **Vulcanize forty minutes.** Shake valve stem on inside of tube to the vicinity of the hole and force it through the opening until the base rests against the inside of the tube, then slip clamp disk (S-T) and spreader (L)—fig. 6, page 550—over valve stem and fasten them securely with lock nut (P).

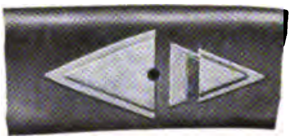


Fig. 6—Valve stem seat repair.

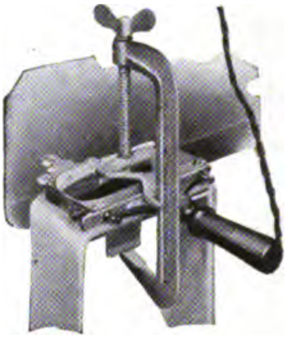


Fig. 7—The electric vulcanizer is connected to lamp socket.

Pointers When Vulcanizing Inner Tube With Steam Vulcanizer.

Time required for vulcanization is determined by the depth of the new material inserted, and not by the size or area of the repair. The following is based upon the maintenance of a uniform steam pressure of 45 pounds.

If tube is in a very much worn condition, place a piece of rubber tubing larger than the pad, under the pad, and vulcanize at a lower steam pressure and more slowly. With a steam pressure of 45 pounds:

For tubes 1-16 in. thick, vulcanize for 7 minutes.
For tubes 1-12 in. thick, vulcanize for 8 minutes.
For tubes 1-10 in. thick, vulcanize for 10 minutes.
For tubes 1-8 in. thick, vulcanize for 13 minutes.

How to test a repair—test the part vulcanized by pressing the thumb nail into it. If it is responsive and elastic to the touch and resembles the rest of the tube in this respect, it is perfectly vulcanized. **If, however, it clearly retains the mark of the nail it is under vulcanized** and should **again be placed** in the vulcanizer and given **a longer heat.** It is best to add **time, not temperature.**

HART NO. 240—Repairing an Inner Tube with the Shaler Electric Vulcanizer.

Troubles Which Necessitate Tire Repairs.

As stated on pages 566, 567, tire troubles are due to external and internal causes.

Due to external causes:

(1) **Tread cuts** which permit dirt to work under tread and cause "loose treads" and "sand-blisters." The moisture also rots the fabric and weakens it.

(2) **Cuts clear through tread and carcass.** When a cut is made through tread and carcass it is a perfect cut, but if blown-out the edges are ragged.

(3) **Fabric broken and weakened inside,** due to striking a stone on tread of tire.

Due to internal causes:

(1) **Blow-outs** are the result of surface or tread cuts. The admission of moisture caused fabric to rotten and pressure of tube blew through the weakened place with a loud report.

The blow-out is also frequently due to a "stone-bruise" as explained on page 566.

(2) **Broken back** is a serious and common injury and is the result of insufficient inflation—see page 567. The layers of fabric separate—this might be termed a "fabric separation."

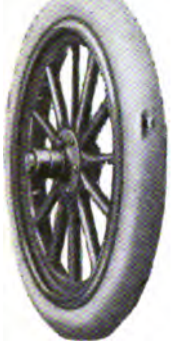


Fig. 1

Fig. 2

Fig. 3

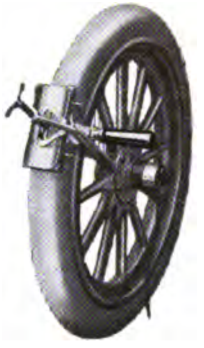


Fig. 4

Importance of Repairing Slight Cuts on Tires.

A set of tires should be gone over at least once every two weeks and the cuts in the treads of the casings sealed up by vulcanizing them. This can be done with tire inflated and on wheel. In this way deterioration of the fabric is prevented and the tires will give a mileage three times as great as that usually given.

Figure 1 shows a tire in which there is a small cut and a "sand-blister" or pocket. If, not repaired at once, sand, dirt and water will be forced into it and rot the fabric until it becomes so weakened the inner tube will blow out through it and ruin the casing.

Figures 2 and 3 show the gash being cleaned and filled with new, live Para rubber (see also page 570).

Figure 4 shows the portable electric vulcanizer in place on the tire. Note that it has not been necessary to remove the tire from the rim. The vulcanizer is left in the position shown, for thirty minutes.

Above instructions cover the external repairs of "tread cuts," "sand-blisters," slight "loose treads."

Instructions for repairing blow-outs and internal troubles, see below and page 575.

Internal and External Tire Repairs—Sectional Method.

There are two methods for reinforcing and building up tires for internal repairs; the "wrapped tread" method and the "sectional" method.

With "wrapped tread" method as explained on page 575, the tire is built up or reinforced from the inside, whereas with the "sectional" method it is built up and reinforced from the "**outside.**"

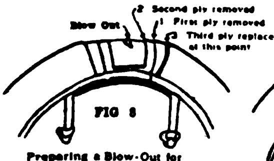


FIG 8

Preparing a Blow-Out for Rebuilding

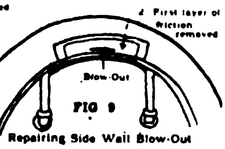


FIG 9

Repairing Side Wall Blow-Out

Explanation of a Sectional Repair.

Fig. 8 illustrates how a blow-out is prepared for reinforcing and building up by the "sectional" method. Note how each layer of fabric is "stepped off." For example, there may be four layers of friction duck (canvas fabric) in the carcass. To proceed, the tread stock is cut down with knife (page 610). The first cut made (fig. 8) goes over each bead and all fabric within these limits is removed. The second cut does not go over the bead but falls inside and borders the first cut by about one inch. This removes two ply of canvas and reverse process, or building up, replaces this canvas, "breaking joints" as a mason breaks joints in stone or brick setting, and the final layer of fabric adds one ply to the original strength. The casing is then reinforced with one layer of canvas on the inside and the total strength, or four ply, has been restored.

Fig. 9 shows a side-wall blow-out in the process of repair. The same principle of stepping off and reinforcing is used, and this "stepping off" is one of the most important points to observe in making good tire repairs.

Sectional Vulcanizing.

The best method for vulcanizing blow-outs or rebuilt repairs is with a steam vulcanizer per pages 574 and 610.

Where the blow-outs are on tread, after repairing, the tire is placed in the sectional or cavity mold (3) fig. 6, page 574 to be vulcanized or cured, and is held down by a clamp (C) fig. 30, page 610. This vulcanizes both inside and outside.

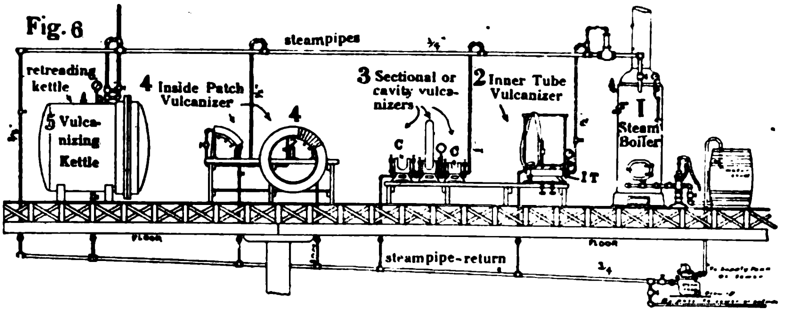
Where the blow-out is on the side-wall, or for a rim cut repair, it is necessary to insert an "air bag" per fig. 29, page 574. Then the bead mold is placed over tire and entire repair cured at one operation.

Where inside repairs only are cured, or where tire is to be dried out before vulcanizing, the "inside patch vulcanizer," at (4), fig. 6, page 574 is suitable.

HART NO. 240-A—Troubles Which Necessitate Tire Repairs. Importance of Repairing Sligh luts on Tires. Internal and External Tire Repairs. Example of the Sectional Method of Repair.

on't try to use so called "self-curing" gum or old rubber—it will not vulcanize.

Fig. 6



Vulcanizers.

Steam vulcaniz are used in the lar er repair shops. Th steam is generated i a boiler from hea produced by almo any fuel which wi heat, as wood, coal, gas, gasoline.

Electric vulcan izers, per pages 57 and 610, are suitab for small shops an garages or hom work and especially desirable for inne tube work.

Example of a Steam Vulcanizing Plant.

The vulcanizing outfit per fig. 6 consists of: (1) boiler; (2) inner tube vulcanizer. The steam passes through the iron plate (I T) and part of tube to be vulcanized is placed on this plate and other part hangs over the rack above it; **(3) sectional molds,** (C, fig. 6), **called cavity molds.** They are used to vulcanize the inside and outside of the tire in sections. These molds (C) are made to take different size tires. See fig. 29 and note a bead mold is placed over tire when it is in the cavity mold (C). These bead molds are made for clincher or straight side beads.

The air bag, shown in fig. 29, is placed in the tire and blown up to a pressure of about 50 lbs. to hold it in shape when being vulcanized in the cavity mold C, fig. 6. Steam passes through the cavity mold; **(4) *inside patch vulcanizer** consists of an iron core shaped like the inside of tire, through which the steam passes. The tire is placed over this core when only inside repairs are being made; **(5) vulcanizing kettle** is used in rebuilding or retreading tires—see page 564 explaining the process of constructing a tire. This is used only for very large shops.

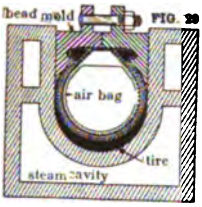


FIG. 29

A small steam vulcanizer using gasoline to generate steam is shown in fig. 2. Note that instead of a cavity mold, as per C, fig. 6, an "outside casing form" is used for outside vulcanizing, and an "inside casing mandrel," similar to "inside vulcanizer" (4) fig. 6 is used for inside repairs. Steam passes through each of these devices. The inner tube plate, through which steam passes is shown in fig. 2, just above the boiler.

Prices For Tire Repair Work.

Section repairs, two to six inches on tires 3", $3.00; 3½", $3.50; 4", $4.00; 4½", $4.75; 5", $6.75. When repairs are over 6 inches add from $1.25 to $5.50.

Inner tube repairs; punctures (single) 50c; each additional puncture in same tube 25c; blow-out in tube, 75c; valve base, 75c; new valve $1.00.

Taking rim off wheel and replacing 25c. **Taking casing off rim** and replacing 25c.

Retreading: The different tire manufacturers supply treads which cover the entire tire and price varies. This work is seldom done only in larg repair shops.

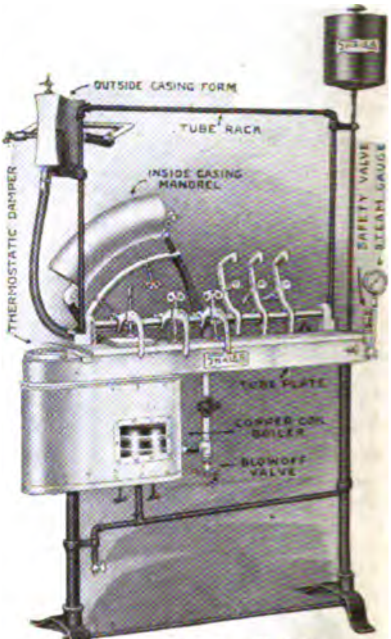


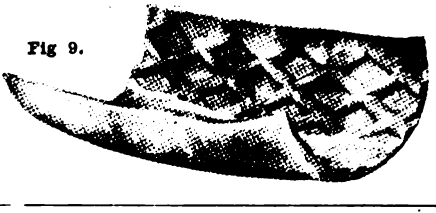
Fig. 2. Shaler steam vulcanizer.

Example of an Anti-Skid Tread Repair.

Should a tire have a non-skid pattern on the tread and a section is to be replaced, the wrapped tread method as explained in the Shaler instruction book is as follows:

Take a piece of canvas (Para coated one side) large enough to cover the repair. Apply to coated side, three layers of ordinary tread stock. Find a good place on tire, dust it with soapstone, and apply this "pad" fig. 9, with the raw rubber side next to tread. Place tire on vulcanizer, wrap tape over pad and tire, tighten tape, put on outside heater (fig. 2) and cure for half an hour. The pad will then have taken an impression of the tread and will be like fig. 9. This may be done while you are waiting for the cement to dry on the repair.

Fig 9.



When the repair is ready to vulcanize place pad over repair, wrap binding tape over it. When heated, the original tread pattern will be duplicated. Save pad for future use and mark it.

If it is unnecesary to replace a portion of the tread, but wish to protect the tread from being flattened by pressure of tape when curing, simply make a thick paste of soapstone and water and then fill depressions in tread with it before wrapping with the tape. When repair is cured the dried soapstone is brushed off and saved for future use.

HART NO. 241—Vulcanizers For Repair Shops. See also page 610 for a Tire Repair Outfit and ools. **Prices to Charge For Tire Repair Work. Example of an Anti-Skid Tread Repair.**

Also used for drying out tires when repairing. **Tires should be free from all moisture** when vulcanizing, moisture turns to steam when heat is applied and forces fabric layers apart, making a weak repair.

Repairing a Blow-Out by the Wrapped Tread Method of Vulcanizing.

The "sectional" method, where repair was built up or reinforced from the outside, was explained on page 573. With the wrapped tread method, it is built up or reinforced from the **inside.**

While we speak of blow-out repairs, this also covers repairs for cuts through tread and carcass, also side-wall and rim repairs.

When Step Cutting Is Necessary.

If the fabric immediately around hole is rotten and shredded so badly that it is impracticable to work it back into the repair, then it will be necessary to remove any loose canvas that may be around the blow-out, "step cutting" it out in two or three steps, similar to fig. 8, page 573, but from the inside. This method however, will not be required once in twenty repairs.

Cut the steps so that the smallest is at least 2" larger in every direction than the hole through the tire, and make each succeeding step about 1½" larger all around the one below it.

Coat all over with cement, working the cement in between plies of fabric at the ragged edges of the damaged part. After first coat has dried for an hour or two put on another coat and let it stand for several hours—over night if convenient.

Cut layers of blow-out canvas (Para coated on both sides) to fit the steps from which fabric was removed and work them thoroughly in place, one at a time. Roll from the center to the edges of the patch, and if air bubbles form under the canvas prick them with an awl and roll them flat. It is necessary that the canvas be laid smoothly and that perfect contact be secured between the different layers.

Then put on another patch an inch larger all around than the largest step. Finish with plain friction canvas or canvas Para-coated on one side. This last layer must be long enough to entirely cover the preceding patches and **reach to the clincher on the outside.** Use from four to six layers of canvas, depending upon the size of the tire and size of the hole through it.

Reinforcing Without Step Cutting.

The following method is where fabric is not rotten and procedure is as follows:

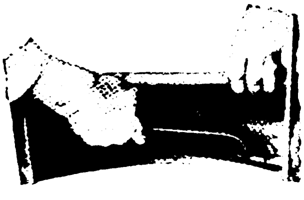


Fig. 20: Clean inside of tire about 6" on each side of hole. Use gasoline to soften. Scrape until bare canvas is exposed, but do not cut fabric.

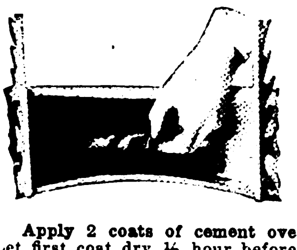


Fig. 21: Apply 2 coats of cement over cleaned surface. Let first coat dry ½ hour before applying the second. Cement hole through tire thoroughly.

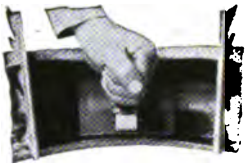


Fig. 22: Cut first layer of fabric (Para-coated both sides) so will extend 1" beyond hole in every direction. Roll smoothly in place, pricking any air bubbles to let air escape.

Then cut a second layer of fabric (Para-coated both sides) large enough to cover the first one and let it extend an inch over it in every direction.

Then cut a third layer (Para coated both sides) 1" larger, and place over second layer in same manner and roll it down.

Then cut a fourth layer (Para coated one side) 1" larger than third layer and apply the Para coated side next to the third layer. In large tires use 5 layers. After the 3rd and 4th layers are applied the patch will look as shown in fig. 23.

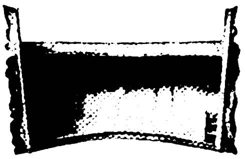


Fig. 23.

Fig. 23 shows appearance of patch after all layers have been applied and rolled down.

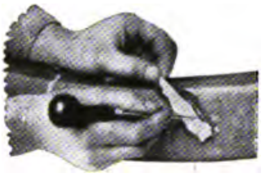


Fig. 24.

Fig. 24: Turn tire over and fill gash with tread stock of narrow strips and press down carefully. No cement is necessary. Do not fill hole too full. Sprinkle inside with soapstone.

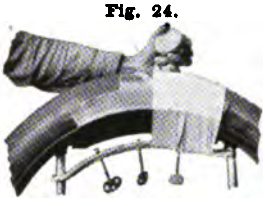


Fig. 25.

Fig. 25: Place tire over the "inside casing mandrel" (see fig. 2, page 574). Lay a piece of waxed paper over outside repair and place bead strips along the bead as shown, then wrap on tape and tighten tension of hand screws so as to pull tire down on mold.

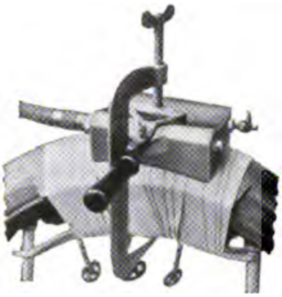


Fig. 26. Apply heat to inside and outside simultaneously.

Fig. 26: Place "outside casing form" or mold over outside repair, apply the steam. Cure for fifteen minutes, then loosen clamp, tighten tape. About 50 minutes in all is required. Larger tires 1 hour at 40 lbs. of steam pressure.

Fig. 27.

Fig. 27 Shows a blowout repair near rim. Same method was used, except the last layer of fabric is brought clear around the bead and up outside of tire far enough for the bead strip to get a good grip, then use the curved side of the "outside form" or mold for rim work.

HART NO. 241-A—Wrapped Tread Method of Repairing a Blow-Out—where repair is built-up o inforced from the inside. The Shaler Steam Vulcanizer, fig. 2, page 574 is used as an example

repair a section of tire where tread is loose—see foot note, page 570.

INSTRUCTION No. 43.

†DIGEST OF TROUBLES: How to Diagnose or Locate Engine Troubles; the Cause and Remedy. Miscellaneous Questions Answered. *USEFUL AND INSTRUCTIVE HINTS AND SUGGESTIONS.

Making a Diagnosis.

Diagnosing automobile troubles requires thought and reasoning. If a person understands the principle and construction of the various parts of a car and some one of the hundreds of troubles occur, then simply reason it out; ask yourself what the trouble is, what could cause that trouble and why. Find if it is ignition, carburetion, cooling, or just what the trouble is, and then figure it out the best you can before proceeding.

Half of the ability to make an adjustment or repair is the ability to discover its necessity. A disease known, is half cured. Never tinker with the different parts of the car, nor labor with the starting crank or have the electric starter turn the engine over many times, without first bringing some little intelligent consideration to bear upon the question of what is most likely to cause the difficulty.

It is of little use to turn the engine over and over by the starting handle or by means of the engine starter, in an effort to set it going. If the engine will not start with a few turns, the chances are that there is something radically out of order, requiring intelligent attention. With the carburetor giving a correct mixture, the ignition system affording a hot and effective spark, and everything else apparently all right, it should be as easy to secure an explosion on the second stroke as on the sixtieth. So if the engine will not start with the second or third attempt it is not likely to start with three or four hundred attempts; consequently it is better to find out the trouble than to turn the engine over indefinitely and run the battery down.

Before an Engine will Run there are Two Essentials.

Always remember when diagnosing troubles that there are two essentials necessary before an engine will run. First, gasoline; second, a spark.

The gasoline must reach the inside of the cylinders and the spark must be there at the proper time to ignite the gas. If you have both, something is bound to happen, even though it is but a single explosion.

Next, remember that even though you have a spark and gasoline—the engine will not run **properly** if the gas does not enter the cylinder at the right time "and stay there" and be in a proper gaseous form.

The gas cannot be ignited regularly if there is not a good, hot spark at the correct time.

Next, remember that if an engine is not properly lubricated and cooled it will **heat,** and if too cold, heat must be applied for proper carburetion. (see page 155.)

Therefore, in summing up the chief troubles, we find that most troubles are due to ignition, carburetion and lubrication.

If trouble occurs, first find which of the three headings the trouble comes under and then reason it out.

The object of this digest or condensed form of troubles and remedies is to simply give you an idea what would likely cause certain troubles and what would likely remedy them. The reader will then decide which one is most likely the trouble and if he does not know the meaning of certain adjustments called for, then turn to the index, find the subject mentioned and read up on that subject.

Reason Out the Cause First.

In dealing with engine troubles one should always try to figure out the possible cause of a trouble before starting to adjust something that does not need adjusting.

An adjustment never should be changed without a knowledge of why the change is made, the effect the change should have and how to restore the mechanism to its original adjustment.

When the possible cause of trouble can not be imagined, then begin with a careful examination of all the features of the engine that are apt to give rise to the trouble.

If nothing out of order is found, then begin testing out the various features, beginning with the easiest and most accessible and thoroughly complete each test before starting on another possible cause.

For example: If your ignition system is suspected, the easiest thing to test would be the spark plugs, first find the faulty plug, then proceed from the spark plugs to the wiring communicating between the plug and the magneto, then examine the battery connections, the switch connections and, last of all, the adjustments of either the coil or magneto.

Do not examine a spark plug and then leave it and try a few carburetor adjustments and later come back for another spell of tinkering with the ignition, etc.

If you suspect the ignition system, go to it from beginning to end in a SYSTEMATIC manner before proceeding with the carburetor. And when you have started on the carburetion system, stay with it until you have made sure of the operation of every feature of it between the engine cylinder and the fuel supply.

---

*See Instructions 45 and 46D for Useful Devices for the Repair Shop and Repair Shop Hints.

†See page 419 for "Digest of Lighting Troubles." Use the Index.

Systematic Trouble Hunting.

By a process of elimination treating with the known quantities. The unknown quantities are discovered by the mere fact that they are what is left. In looking for trouble, it will be desirable to take up the unknown quantities in the order of their naming, or in the order of convenience, considering a given design of engine, and transfer them to the column of known quantities, ultimately discovering the real difficulty. It is a wiser plan to thus proceed, than will be true of a haphazard idea with the probability that the real difficulty will escape detection.

CASE NO. 1. When engine will not run, and you are reasonably certain that:

- the ignition is in working order;*
- the compression is normal;
- the carburetor is working properly;
- the exhaust valve is tight;
- the inlet valve is tight;
- the gasoline supply is adequate;
- the gasoline pressure is sufficient;
- the gasoline is free from water;
- the gasoline supply valve is open;
- the gasoline piping is not stopped up;
- the intake manifold is tight;
- the carburetor control system is not deranged;
- the cylinders are properly scavenged;
- the timer is in good order;
- the magneto appears to be in working order.

Then it stands to reason that one or more of the following is the probable cause:

- the gasoline is poor grade or cold and does not vaporize readily;
- the timing system is deranged;
- the points of the spark plugs are separated too much;
- the wiring is defective, as an open or short circuit;
- the half-time gears have been removed and put back out of proper mesh;
- the contacts of the timer are not good, due to weak springs, or accumulations of dirt if the brushes are not worn out;
- the battery is run down, or the magnets of magneto are demagnetized;
- the camshaft has been taken out and put back wrong;
- the order of firing has been deranged;
- the valves (one or more) after they are opened by the cam action are in a sticking condition and stay open;
- the relation of gasoline to air of the carburetor is poor, although the carburetor appears to work all right;
- the spark advance mechanism is either deranged or the spark position is wrong for the starting and running of the engine.

CASE NO. 2. The engine fails to operate and you are reasonably certain that:

- the ignition is in working order;
- the compression is normal;
- the exhaust valves are tight;
- the inlet valves are tight;
- there is gasoline in the tank;
- the gasoline is free from water;
- the gasoline supply valve is open;
- there is no impediment in the gasoline pipe;
- the intake manifold is tight;
- the carburetor control system is in good order;
- the gasoline tank pressure is sufficient;
- the cylinders of the engine are properly scavenged;
- the cylinders are not fouled with cylinder oil;
- the cam shaft has not been deranged;
- the half-time gears are meshing properly;
- the timer is not fouled by grease;
- the engine will start after cleaning and timing;

Then it stands to reason that one or more of the following is the probable cause:

- the carburetor float is punctured (if of copper);
- the carburetor float is loggy (if of cork);
- the gasoline is poor grade or cold and does not vaporize readily;
- the gasoline level is too low or too high;
- there is a leak around the float bowl;
- the carburetor nozzle is stopped up;
- the needle valve in the nozzle is out of adjustment;
- the needle valve is worn;
- the gasoline strainer is clogged up;
- the balance levers of the float are stuck;
- there is an impediment in the carburetor passages;
- the air valve adjustment is awry;
- the automatic valve spring is weakened;
- there is lost motion in the valves somewhere;
- one or more of the valves stick;
- there is a leaky gasket at a joint;
- water is lodged in the float-bowl;
- the air vent of the float-bowl is stopped up;
- the float sticks in its guides;
- liquid gasoline lodges in the intake manifold;
- a new nozzle has been put into the carburetor and it is too small or too large;
- the method of heating the auxiliary air is insufficient;
- the carburetor is getting too much air;
- the engine is not being supplied with the proper mixture.

CASE NO. 3. The engine refuses to operate and you are reasonably certain that:

- the ignition system is in working order;
- the carburetor appears to be in working order;
- the gasoline supply is adequate;
- the engine cranks freely;
- the engine starts without difficulty;
- the engine does not stall when it is given work;
- there is no noticeable absence of power.

Then it stands to reason that one or more of the following is the probable cause:

- the gasoline is poor grade or cold and does not vaporize readily;
- the compression is poor;
- there is a leak in the inlet valve;
- the exhaust valves are not tight;
- the piston rings are worn;
- the valve stems are deformed;
- the valve stems stick in the guides;
- the valve seats are pitted;
- the valve springs are weak;
- the tappet adjustments are awry;
- there is a crack in the cylinder;
- the piston rings are gummed up and stick;
- the cylinder head covers are not tight;
- the piston head is cracked;
- the spark plugs are not screwed in tight;
- there is an obstruction in the intake passageways;
- a cam is loose on the cam shaft.
- the half-time gears are slipping on the shaft;
- the tappet rods stick, or some other mechanical imperfection prevents the valves from closing.

---

*"**The ignition in working order**" means that you **know** there is a good spark at points of all spark plugs, because you tested each plug as per page 286 and 287. You also **know** that the battery current is strong enough to ignite the gas under pressure, because you tested the battery as per page 450. It is assumed that you **know** this before starting other deductions or tests.

†A DIGEST OF TROUBLES; Cause and Remedy.

Ordinary engine troubles generally are of three kinds: Either the engine will not start, it runs irregularly, or it runs regularly, but with a noticeablo falling off in power.

The following refer principally to ignition and carburetion troubles, also see pages 407, 411, 408 for starting motor troubles.

ENGINE FAILS TO START.

(1) LACK OF GASOLINE: See that there is gasoline in the tank and that the shut-off cock is open. Make sure that gasoline is flowing to the carburetor by priming or pushing down the carburetor float. If the carburetor is too full the gasoline will drip. If the carburetor is not full enough, look for a stoppage in the gasoline pipe and see that the vent hole in the tank cap is open, see (73) this instruction.

(1A) CARBURETOR NEEDS PRIMING: Either prime carburetor or close air intake valve. (see pages 153 156 and foot notes, page 489).

(2) *POOR QUALITY OF GASOLINE: Some of the gasoline offered for sale is of such poor quality that it will not vaporize when the engine is cold. The gasoline may contain water, which will freeze in cold weather and clog the gasoline pipe. Old or stale gasoline may also cause difficult starting.

(3) TOO MUCH GASOLINE: The cylinder may be flooded with gasoline; spark plug soaked. Open the relief cocks, cut off throttle and crank engine until excess is eliminated and an explosion occurs. Then close relief cocks, open throttle only partial way and try cranking again; engine ought to start. Float may be loose. (see page 167 and foot note page 489.)

(4) NO PRESSURE IN FUEL TANK: If the system is a pressure fuel system, then use the hand pump and try priming carburetor. (see page 164, fig. 2.)

(5) LACK OF IGNITION CURRENT: If battery ignition, see if battery is strong. Remove one of the spark plug wires and hold it about ⅜ of an inch away from plug and terminal and see if the spark jumps the gap when the engine is cranked.

(6) IF STARTING MOTOR FAILS: See Instruction 29 and pages 404, 416.

(7) SPARK PLUGS: Spark plugs may have become sooted from over-lubrication or if they have seen considerable usage the points may be burned and corroded. If water has been splashed on the engine when it was not, the porcelain of the plugs may be cracked. See that the sparking points are perfectly clean and that the gap does not exceed 1-32 of an inch for coil ignition or 1-64 of an inch for magneto ignition. (see charts 112 and 113.) Also see pages 298 and 235.)

ENGINE STARTS BUT MISSES.

(8) CARBURETION ADJUSTMENTS: If on a cold day and engine has just been started, wait a few minutes for engine to warm up—closing air intake.

If missing still occurs with popping back or "sneezing," this indicates the mixture is too lean; give the needle valve of carburetor a slight opening until engine runs smooth. If no needle valve is provided, give less air in the auxiliary air valve, see pages 170, 153, 168 and foot note page 489.

(9) IGNITION: If missing continues after engine is warmed up, and more gasoline is fed as per (3), examine the spark plugs and test as per (3). (Also see charts 113 and 112.) Weak battery: if coil and battery ignition. (see pages 241 and 450 and Instruction 29).

ENGINE STARTS BUT "POPS" AND "SNEEZES" IN CARBURETOR.

(10) CARBURETION: See (8), also page 170.

ENGINE STARTS BUT WILL NOT PULL.

(11) CARBURETION: See (8) or there may be an over rich mixture. This would be indicated by black smoke.

(12) THE VALVES: May be leaking and there might be poor compression.

(13) IGNITION: The spark may be weak, this, however, would be indicated by missing. Test battery—see pages 241 and 450.

ENGINE RUNS REGULARLY FOR A FEW MINUTES AND THEN STOPS.

(14) CARBURETION: In cold weather this is more liable to occur, until engine is warm; give slightly more gasoline by closing air valve (if one is provided); gasoline may not be flowing freely to carburetor. Prime carburetor and see if it drips. There may not be enough gasoline; closing air valve will détermine. Maybe too much gasoline (see 3).

(15) IGNITION: Battery may be weak. Ignition may be retarded too much. If there are two systems of ignition try the other one.

ENGINE STOPS SUDDENLY.

(16) CARBURETION: Lack of gasoline. Stoppage of gasoline pipe (prime carburetor and if no gasoline, examine tank, then fuel strainer). see (73).

(17) IGNITION: Loose wire. Short circuit, loose switch connection. If magneto ignition, switch to coil and battery. Weak battery. Points of interrupter may be closed by pitting, see pages 298, 300 and 249.

(18) A sudden stoppage is almost always due to ignition trouble, for gasoline trouble will stop engine slowly.

ENGINE STOPS SLOWLY WITH MIS-FIRING.

(19) CARBURETION: See (16). The needle valve sometimes jars itself closed.

(20) When an engine stops slowly, the explosions becoming weaker and weaker until they cease, it is likely due to gasoline trouble. The fault will be found in the failure of the mixture to reach the cylinder. (see 73.)

(21) IGNITION: Batteries exhausted, plugs fouled through over lubrication.

ENGINE LOPES OR LOADS UP.

(22) CARBURETION: When engine slows down irregularly, speeding up and then slowing down again as though fitted with a governor and if throttle be closed further, in order to slow down more, engine stops. Air has leaked in between carburetor and cylinders. Examine gaskets around the joints of inlet pipe or where carburetor is attached to intake manifold. Too much gasoline will also cause "loping." Cut down on the carburetor gasoline feed.

(23) IGNITION: The spark may be set too far advanced. If this is the case, loping is likely to occur when spark is fully retarded. Therefore test the time of ignition, (see page 317 "Testing ignition advance.")

LACK OF FLEXIBILITY.

(24) CARBURETION: This trouble is almost exclusively a carburetor fault and is due to the fact that the auxiliary air intake being so constructed that it furnishes an abundance of air on high speed, is not sensitive enough on low, when the throttle is nearly closed the engine stalls; or when the throttle is suddenly opened there is no "get away" because the auxiliary air inlet valve allows an inrush of air, forming a mixture good enough for high speed running but too weak for "pick up" purposes. This calls for careful adjustment of the auxiliary air valve and gasoline needle valve. (see pg. 150 to 164.)

---

*Very common in cool weather—see pages 153, 161, 155, 170 and foot note bottom of page 489.

†See page 419 for "Digest of Lighting Troubles," pages 457, 422, 416, 458 for "Storage Battery Troubles."

*ENGINE MISSES EXPLOSION.

(25) DEFECTIVE OR DIRTY SPARK PLUG: With the engine running idle, short circuit the spark plugs one at a time by touching a screwdriver from the metal of the cylinders to the terminals of the plugs. (see pages 236 and 237.) This prevents the plug from firing and when one is short circuited—that makes no difference in the running of the engine—you have probably located the plug at fault. If the spark plug wire is properly connected to the magneto, either clean or install a new plug in place of the one that has been found defective. If a vibrator coil, see chart 112. (also see 17).

(26) **SPARK PLUG GAP TOO WIDE:. The distance betwen the spark plug points should not exceed 1-32 or 1-64th of an inch. (see 6.) Examine interrupter points on magneto. (see pages 298 and 297). Weak battery.

(28) TOO LEAN A GASOLINE MIXTURE: If the engine misses with a popping noise in the carburetor, the indications are that too much cold air is being admitted through the air regulating valve, the carburetor jets have become clogged with dirt, or there is a partial stoppage somewhere in the gasoline pipe connections. See that carburetor intake header gaskets are perfectly tight and do not admit air, which would thin the mixture. (see pages 162, 168 and Instruction 13.)

(29) LOOK FOR GASOLINE TROUBLE: Dirt in gasoline tank over outlet, dirt or water in carburetor, float leaking, jet in carburetor clogged up, supply cock loose, inlet valve sticking or leak in inlet pipe, weak exhaust valve spring, may be a leak of air in inlet pipe.

(30) If the engine misses, and the following explosion is accompanied by an explosion in the muffler; ignition is at fault, for the charge has reached the cylinder correctly, but has been exhausted without being exploded.

**ENGINE MISSES ON HIGH SPEED.

(31) IGNITION: Weak battery (if coil and battery ignition, see page 450). If the engine misses at high but not on low or on a hard pull, then it is evident the spark plugs are O.K.

The contact screw in the magneto breaker box needs screwing up (page 297 and 298.) A word of explanation on this; the engine may fire all right at lesser speeds, because the speed is slow enough and the contact is long enough to allow the coil to build up, but at high speeds the contact is too short, consequently a slight turn of the contact screw is needed.

Try switching to the other ignition system, if a dual system is provided, this will determine which ignition system is at fault.

The coil may be defective. see index and pages 235, 236, 249 and 253 for "Testing a coil."

(32) CARBURETION: The carburetor may have been adjusted for slow speed, but requires more gasoline on high speed, or it may be getting too much gasoline. Proper adjustment of carburetor ought to suffice.

**ENGINE MISSES ON LOW SPEED.

(33) IGNITION: If magneto ignition, the cause may be due to the slow speed of magneto and weak current generated. Try advancing the spark more. Also examine the interrupter points.

Examine spark plug points (see 7). If not remedied, try switching to the other system of ignition. If missing still occurs, then there are two other points to consider; loose connection or a broken down coil, if one coil is used for both systems, as a low tension magneto—see page 241.

(34) A SPARK PLUG MAY BE FOULED: It has been known that a bad plug will not cause missing at all speeds (page 235).

(35) CARBURETION: Mixture at fault—readjust slow speed adjustment. The float may be too low giving over rich mixture.

(36) THERE MAY BE A LEAK IN THE INTAKE PIPE: This is a very common cause for missing at low speeds, and is best detected by allowing the engine to run at the missing speed. Take a squirt can full of gasoline and squirt around all the intake pipe joints. If you detect any difference whatsoever in the running, there is a leak. The remedy is obvious, see pages 162 and 171.

ENGINE MISSES AT ALL SPEEDS.

(37) IGNITION: Defective spark plug (see 7 and 25.) Loose connection. Weak battery. Loose switch parts. Broken wire. Slight short circuit (see page 241, and charts 112 and 113.)

(38) CARBURETION: see pages 166 to 171.

†ENGINE DOES NOT DELIVER FULL POWER.

(39) VALVES: Leaky exhaust valves are usually the cause, test springs. Compression is lost. Valves need regrinding. Timing of valve may be wrong. Exhaust and inlet may not open at correct time. See page 110 for "checking valve timing," and page 92 and chart 250 on "valve grinding" and pages 94 and 95 "valve clearance." Weak inlet or exhaust springs. Examine cams for wear.

(40) CARBURETION: Too rich a mixture (see pages 166 to 171).

(41) OVERHEATING OF ENGINE: Lack of oil. Circulation system defective (see page 191.)

(42) IGNITION: Timing of ignition may be wrong. Set too far retarded or too far advanced. (see page 249). Weak ignition. Defect in distributor.

(43) MISCELLANEOUS CAUSES: Dragging brakes, leaky piston rings, lack of lubrication. Tight bearings. Flat tires. If new piston rings fitted they are not fully set, use plenty of oil.

††ENGINE OVERHEATS.

(44) VALVES: The exhaust valve may not open early enough to pass out the burnt gas.

(45) CARBURETION: Too rich a mixture (see pages 166 to 171) or driving with throttle open too far and spark retarded too much.

(46) IGNITION: Running on retarded spark invariably causes heating (see page 67 and 68.) Test the ignition timing, see index.

The spark lever should be raised up or advanced as far as possible at all times without causing the engine to knock, also see page 319, for "Spark control and overheating."

(47) LACK OF LUBRICATION: Examine the oiling system, see bottom of page 201.

(48) COOLING: Constricted water circulation (see page 191 and 193); examine the water circulation and pump. Under sized radiator.

(49) CARBON DEPOSIT: See page 201 and 202. Choked exhaust.

(50) SLIPPING FAN BELT: Tighten the belt.

---

*See pages 236, 298 and index. ††When engine overheats by steaming, due to frozen water—feel of radiator at bottom—if cold it is frozen, if warm then circulation is o.k. and trouble is due to lack of water or something else—see also pages 193, 788, 800.

†See page 586, "Spark Plugs Indicate Condition of Valves, and index "Engine, Why Loses Power."

**See pages 235, 297, 298 and index.

(51) Brakes dragging:. Examine the brakes with rear wheels jacked up.

(52) BEARINGS: If engine is new or just overhauled, the bearings may be too tight. Put in plenty of oil and run until loosened up, see page 203.

(53) DRIVING TOO LONG ON LOW GEAR: This is bad practice and should be avoided.

Note.—Refer to page 188 and note the "motometer." This is an excellent device to assist in diagnosing overheating troubles. Overheating is always manifest when engine begins to run slow and pounds.

ENGINE KNOCKS.

(54) IGNITION: The most common knock is the ignition knock, caused by too much advance of spark. Back lash, in timing wheel teeth, see pages 638, 790 and index for "knocks."

(55) BEARINGS: The connecting rod or main bearings may be loose. (see index for "testing", also "tightening bearings.")

(56) CARBON DEPOSIT: This is also a frequent cause, see page 201 to 203; also see index for "cleaning carbon."

(57) LOOSE OR WORN PISTONS: Will cause a knock as explained in chart 254.

(58) CARBURETION: Too rich a mixture will cause a gas knock.

(59) ENGINE OVERLOAD ON HILL: Shift to lower speed.

ENGINE WILL NOT STOP WHEN SWITCHED OFF.

(60) IGNITION: If firing is regular the switch is defective. If firing is irregular, preignition is the cause. Caused by poor oil as explained on page 202. This carbon hardens and becomes red hot, hence "pre-ignition," (see index "pre-ignition.")

Stop engine by closing throttle and as soon as the engine cools, locate the cause.

(61) MISCELLANEOUS OTHER CAUSES: Overheating as explained from (44) to (53), this instruction, may be the cause.

ENGINE RUNS WELL BUT CAR DRAGS.

(62) CLUTCH IS LIKELY SLIPPING: The spring needs tightening. If leather faced cone type; too much oil on the leather. Clean with gasoline squirted on with an oil gun. If this don't hold, use Fullers earth (last resort). If multiple disc type; clutch spring at fault or plates worn.

A slipping clutch is detected by the engine speed not conforming with speed of car when throttle is opened. This ratio between car and engine is soon learned by experience.

CLUTCH DRAGS.

(63) IF CONE TYPE: The clutch may not clear the fly wheel when thrown out. If multiple disc type; the oil may be too heavy and sticks to plates, (see instruction 15, page 203).

CLUTCH GRABS OR IS FIERCE.

*(64) IF CONE TYPE: Leather too dry, clean with gasoline (see 62) then put on castor oil or neats foot oil to soften.

If multiple disc use lighter oil after cleaning. Spring may be too tight, (see repair subject "care of clutch.")

OIL ON CLUTCH LEATHER—(cone type)—see page 38 and index, "clutch repairing."

(67) CAUSE: Too much oil in crank case—oil works out engine bearing.

ENGINE BACK FIRES IN MUFFLER.

(68) IGNITION: Usually occurs when coasting with spark off and retarded and suddenly throwing on switch, thereby firing charges which have entered muffler unfired.

(69) CARBURETION: Mixture too weak to fire, or mixture right but sparking wrong, one cylinder missing fire and pumping explosive charges into muffler which ignites from heat of the next exhaust change. Missing of ignition, valves leaking. Gasoline supply failing. (see page 168 to 170.) Remedy: (1) Examine as in last section; particularly see if the plug points are too far apart. (2) See that all cylinders are firing regularly. (3) Adjust carburetor. (4) See if plenty of gasoline in tank.

CRANK CASE BECOMES VERY HOT AND ENGINE WEAK.

(70) CAUSE: Serious leak of exploded gas past piston rings—rings worn or broken—crack in head of piston—piston pin loose in piston and allowing gas to escape along bearing. See repair subject for "testing piston ring leaks."

OVERHEATING OF EXHAUST PIPE AND MUFFLER.

(71) CAUSE: Carburetor trouble over-rich mixture, valves out of time, very late spark, running too long on low gear, using too much gas, exhaust throttled, insufficient lift on valve or choked muffler.

This condition is the result of something by which the mixture is not completely burned in the combustion space, but continues to burn in the exhaust pipe and muffler.

A mixture that is too rich or too poor, usually the former, will burn slowly and will still be burning during the exhaust stroke.

If the exhaust valve opens too soon, the charge will escape before it has done its work.

Very late ignition will not give enough time to permit the charge to be burned before the exhaust valve opens.

ENGINE MAKES AN UNUSUAL HISSING NOISE.

(72) CAUSE: Spark plug porcelain broken, joint between engine and exhaust pipe loose, exhaust pipe cracked, compression cock worked loose, spark plug not tightly screwed into cylinder, valve caps may be loose; probabilities are the exhaust pipe or a spark plug is loose.

GASOLINE FAILS TO REACH THE CARBURETOR.

(73) CAUSE: Gauze strainer in base of carburetor choked—obstruction in the supply pipe—air lock at a bend in supply pipe—(see page 192, refers to water) pressure leakage from tank, or if a gravity tank it may be air-bound—floating obstruction in gasoline tank covering the gasoline outlet—gasoline pipe near exhaust pipe causing a vapor lock. Vent hole in filler cap clogged.

CONTINUAL EMISSION OF SMOKE FROM MUFFLER.

(74) CAUSE: Engine being over-lubricated; readjust lubrication to give a slower rate of oil flow—the emission of black smoke indicates that the carburetion is too rich. (see pages 202 and 169). Piston rings leak.

CRACK IN CYLINDER.

(75) EFFECT: Water in combustion chamber or in crank chamber—air bubbling through radiator on pulling engine over compression. (see page 713, "rusting up a crack.")

CARBURETOR DRIPS.

(76) CAUSE: Float valve mechanism out of order; examine float and grind the float needle valve.(see page 167.)

ABNORMAL NOISE FROM TRANSMISSION GEAR.

(77) CAUSE: (Other than due to unskillful changing of the gears)—want of lubrica-

---

*Numbers 65 and 66 omitted by error.

tion of gears in change-gear box or bevel drive on back axle—pinions damaged—teeth broken or worn down—nut loose in gear box and fouling gears—clutch drum or fly wheel loose—universal joints on transmission shaft badly worn or damaged—bearings in gear box worn, allowing shafts to rock about—sliding member of clutch out of alignment with cone (sets up harsh grating noise)—wear of jaws of positive clutch in gear box.

SQUEAKS AND SIMILAR NOISES.

(78) CAUSE: **Fork actuating clutch wants lubrication—one or more bearings overheating and want of lubrication—one or more of the brakes partly on—bearings of spring shackles want lubricating(on some cars the spring ends work in a slide, which requires occasionally lubricating)—valve stems running dry in the guides. Fenders and hoods are usually the cause of most noises.**

LUBRICATOR STOPS WORKING.

(79) CAUSE: **Oil pipe choked—feed nipples choked—pump shaft may be broke, usually due to clogged pipes. May need priming. Loose connections.**

OIL FEED GAUGE DOES NOT SHOW FLOW OF OIL.

(80) SEE IF OIL IN CRANK CASE. **Clean Strainer. Examine pump and pipe connections. Oil may be too cold to flow. (see page 199). Oil pump may need priming.**

OIL LEAKAGE FROM ENGINE.

(81) CAUSE: **Bearings badly worn and passing out bearing journal—gaskets not tight—screws loose. Crank case flooded with oil (lubricator working too rapidly). Cap screws holding lower crank case not tight. Gaskets leaking.**

For ignition troubles see pages 233 to 241.

For magneto troubles see pages 297 to 300.

For carburetor troubles see pages 166 to 171.

For starting motor troubles see pages 416, 422 and Inst. 29.

For cooling troubles see pages 189 and 191.

For generator troubles see Inst. 29.

For carbon troubles see page 202 and index.

For storage battery troubles see pages 457, 458, and 471.

For miscellaneous repairs and adjustments see Instruction No. 46.

QUESTIONS ANSWERED.

The following are some of the questions answered by A. L. Dyke in the St. Louis Globe-Democrat and the New York Times—Automobile Query Columns, during the past few years. The questions and answers have been partially classified.

First Auto Show.

Q.—What year was the first automobile show held in Chicago and also New York?

A.—The first show held in New York was in November, 1900, at Madison Square Garden, under the auspices of the Automobile Club of America. A feature of the show was a board hill built on the roof of the garden, to prove that the new vehicle would not only propel itself, but would climb a grade. The novelty of the idea appealed to the public. The first automobile show in Chicago was at the Coliseum in March, 1901. Eighteen vehicles were displayed. The gate receipts were $8,200. Mr. Sam Miles was the manager.

First Four-Cycle Gasoline Engine.

Q.—Who invented the first gasoline engine?

A.—Nicolaus August Otto, Deutz, Germany, on August 14, 1877, was granted patents covering the four-cycle engine and the principle of compressing the mixture before exploding it. This is the principle still used on automobile engines at present. The conception of compression and four cycles of operation was not, however, original with Otto. He combined these ideas into a practical engine. They were twelve years in the making, and three countries participated in their evolution. The conception started in 1862, when a Frenchman, Alphonse Beau de Rochas, obtained a patent and wrote a pamphlet on the four-cycle engine. Six years later Boulton, an Englishman, secured a patent covering the use of compression in an engine. However, Boulton failed to work out the necessary means for compression in a practical way.

First Power Propelled Vehicle.

Q.—When was the first power-propelled vehicle invented?

A.—Experiments date back to 1770, when Joseph Cugnot, a French engineer, built the first automobile. He constructed a steam automobile that hauled 2½ tons three miles per hour, and this vehicle is still preserved in France. In 1802, the first practical steam automobile was built by Richard Trevitluck of England, using a crank shaft for the first time and driving by gears from the engine to the road wheels. In 1821, Julius Griffiths of England built the first comfortable steam vehicle, the first vehicle to have a coach design of body, with seats carried on springs, as they are today. In 1831 Summers & Ogle of England built a three-wheel tubular boiler and two-cylinder engine which attained a speed of thirty-two miles per hour. The first motor vehicle to carry passengers regularly for hire was built by Walter Hancock of England in 1834. The motive power was steam.

First Pneumatic Tires.

Q.—(1) Who invented the pneumatic tire? (2) What year did American manufacturers of automobiles begin to use the double tube tire? (3) What were the prices of tires from 1900 to 1915?

A.—(1) At present the honor of inventing pneumatic tires is disputed between two claimants: R. W. Thompson, a Scotchman, and John Dunlap, an Irishman. The former devised an automobile rubber tire in 1889, but it never came into use, as it was a very crude affair and seemed of no practical service. Thompson's tire was a single tube appliance and was invented in 1845. The solid rubber cushion tire and the single-tube air tire was used considerably in 1899 and 1900. The double-tube penumatic tire did not come into general use on automobiles until 1902. (2) Single-tube pneumatic tires were generally used up to 1903. Double-tube tires were in use in 1902 and were extensively adopted in 1908. (3) For a 30x3½-inch single-tube tire the price in 1900 was $28; in 1901, $25; in 1903 the double-tube tire casing and tube cost $41; 1913, $21.95; 1915, $14.30.

First American Auto Road Race.

Q.—Where and when was the first American Automobile Road Race run in America?

A.—Motor Age, April 19, 1900, says: "America's first auto road race was run over a fifty-mile course on the famous Merrick road on Long Island yesterday morning. A. L. Riker, with a five horse-power electric racing wagon, won by a quarter of an hour; time, 2:03:30. S. T. Davis, Jr. in a steam Locomobile, four and a half horse-power, was second; time, 2:13:27. Alexander Fisher, in a gasoline runabout built by the Automobile Company of America was third; time, 2:30:01." The article further states that the racers wore auto caps, goggles and mouth protectors. Riker wore no auto togs at all, but got there just the same. This speed is averaged now almost daily on the streets.

First Auto Race.

Q.—Where was the first automobile race held in America? How many cars started? How many finished?

A.—Chicago made the earliest attempt at an automobile race, November 25, 1895. Six cars started over a course of fifty-four miles, from

Jackson Park to Evanston and back again, for a prize of $5000 offered by the Chicago Times-Herald. Four of the cars were propelled by gasoline and two by electricity. Two cars finished. Charles E. Duryea won in ten hours and twenty-three minutes. The course was covered under highly unfavorable conditions, the roads being heavy with mud and snowy slush.

†Speed, Motorcycle vs. Auto.

Q.—What is the best time ever made by a motor cycle? Some say the motor cycle is faster than any automobile.

A.—The best time ever made by a motor cycle was one mile in 37 seconds, or less than 100 miles per hour.* This was accomplished by Lee Humiston at the Los Angeles Motordrome, November 5, 1911. The fastest automobile time ever made was by a Fiat, driven by Arthur Duray at Ostend in 1913; time 142.9 miles per hour.

Earnings of Racing Drivers.

Q.—What are the earnings of racing drivers?

A.—During 1915 Resta earned $37,750; Anderson, $37,000; Cooper, $31,750; De Palma, $24,600; and Rickenbacker, $24,000.

**Castor Oil as a Lubricant.

Q.—Do the race drivers use castor oil exclusively in their high-speed engines, or is it compounded?

A.—Very few racing drivers use pure castor oil. In each of the big races not more than one or two drivers have used it. Nowadays, when castor oil is used, it is not compounded, but in former years it was sometimes mixed with alcohol. It may be that some drivers are secretly using their own mixing process.

Auto Club of America.

Q.—In what year was the Automobile Club of America organized, and how many cars were produced that year?

A.—On Wednesday, January 7, 1899, a public meeting was held at the Waldorf-Astoria Hotel, New York, and as a result the National Auto Club of America was chartered on the following August 6. Six hundred machines were produced in 1899.

Q.—When was the jump-spark coil invented and first used?

A.—In February, 1852, Emperor Napoleon of France offered 50,000 francs to the man who could produce the most important electric invention during the next five years, which period was later extended five years. This award was finally given to H. D. Ruhmkorff, a Paris instrument maker, for inventing the jump-spark coil, often referred to as the Ruhmkorff coil or high-tension coil. This coil, however, was first actually developed by Prof. Charles G. Page of Washington, D. C., following the researches of Faraday, Joseph Henry and W. Sturgeon, about 1831, and really should be more properly termed Page's coil.

First Rubber Tire.

Q.—When was rubber first discovered and who made the first rubber tires?

A.—The first mention of rubber was in 1525, when the Spaniards in Mexico saw the natives playing with balls of a remarkable elasticity. In 1770 it was suggested as an eraser for pencil marks. In 1823 Macintosh of Manchester, England, found that rubber would dissolve in benzine and began making waterproof fabrics. In 1832 the Roxbury Rubber Company was formed in Massachusetts to engage in this work and Charles Goodyear was one of its employes. Goodyear discovered vulcanization in 1835. In 1842 he began producing rubber shoes. The first use of rubber tires was when Dietz in 1835 patented a rubber cushion applied to an iron ring or tire. R. W. Thompson, an Englishman, December 10, 1845, patented the first pneumatic tire.

Right Side of an Automobile.

Q.—Which is the right side of an automobile?

A.—The right side of an automobile is always understood to be the right of the driver when seated in the car, not of the person standing in front of the car.

Garage and Limousine.

Q.—Kindly give me the derivation of "garage" and "limousine." I judge both are of French origin.

A.—Yes, both words are of French derivation. Garage is a derivation from "gare," a station or terminal for either railway trains or boats. "Garage," as a noun, means, in both French and English, a place in which motor cars are stored. The term "limousine' was originally applied to a cloak worn by the inhabitants of Limousine an old province of Central France. It was later extended to the covering of a carriage, and then to a type of motor car body with a permanent top projecting over the driver.

Pronounciation of Auto Words.

Q.—(1) What is the correct pronounciation of chassis? (2) Of Fiat? (3) Of Peugeot? (4) Has the Losier motor of the 1913 and 1914 light six, ball bearings on the main and connecting rod bearings of the crankshaft?

A.—(1) Chassis is pronounced shase, the a is like a in ask and the e is like e in event. The accent is on the first syllable. (2) Fiat is pronounced Fee-at, accent on the first syllable. (3) Peugeot is pronounced Pu-jo, the u being like u in pur and the j being soft. (4) The light six Losier did not have ball bearings on crank shaft or connecting rods.

Meaning of Words used in Connection with The Auto.

Q.—Will you oblige me with the meaning of following words I see quite often used in connection with the automobile, cardan joint, pantasote, bore and stroke, accelerator.

A.—Cardan joint is the same as universal joint. Pantasote is an imitation leather used for upholstering and tops. The bore of an engine cylinder is the measurement across the circular space in which the piston moves. It is another term for the internal diameter of the cylinder. The stroke is the length of the path through which the piston moves in the cylinder, and is exactly equal to the diameter of the circle made by the crank pin. The purpose of an accelerator is to open the throttle by means of a pedal on the foot board independent of the hand throttle. It opens the throttle more quickly than the hand throttle, hence the term "accelerator."

Water in Crank Case.

Q.—How does water get into my crank case and mix with my oil? The gasoline is strained and the lubricating oil is all right.

A.—Two things may cause the trouble; one of chemical origin, the other ill-fitting piston rings. When gasoline is burned with the proper amount of air the hydrogen and carbon of the gasoline combine with the oxygen of the air to form water and carbon dioxide. Hence, water is always one of the products of combustion and exists in the cylinder in the form of superheated steam. Ill-fitting piston rings and scored cylinders allow gas to blow by, consequently more water will condense in such engines. This is more common with six and multicylinder engines, because there is more ring surface, consequently more chance of leakage. The carburetor adjustment is also important. A mixture containing much gasoline means an excessive amount of water, just as sure as it means a formation of carbon in the cylinder.

High Altitudes.

Q.—Does the water become heated more quickly in a high altitude than a low altitude?

A.—Water boils at a lower temperature in a high altitude because the pressure of the atmosphere, which water must overcome before it can boil or change into steam, is lower in a high altitude. At an elevation of one mile water will boil at a temperature 10 degrees lower than at sea level. In crossing the Rocky Mountains the road is frequently much more than one mile above sea level and water boils away very rapidly.

---

*There are 3600 seconds in one hour. To find the miles per hour, divide 3600 by the time it takes to make one mile. †Figures are not now correct. **See page 918.

Use of Graphite in Engine.

Q.—Can graphite be used in an automobile engine?

A.—Yes. See page 205.

Which is the Best Car?

Q.—I am considering purchasing a car. Advise me which of the three you would advise and the advantages of one over the other—Dodge, Overland, Maxwell?

A.—Comment on relative merits of cars in this department is irregular. All those you name are good cars. I will tell you how I would settle the choice, if I were unable to decide otherwise, go to several used car concerns and ascertain which car brings the best price. This may answer your question. (see pages 527 and 528.)

Ratio of Gearing Leading Cars.

Q.—What is the ratio of gearing (high speed) of some of the leading cars?

Studebaker Four	4 to 1
Studebaker Six	3.7 to 1
Hupmobile	4 to 1
Saxon Four and Six	4.75 to 1
Grant	4.50 to 1
Reo	4 to 1
Empire	4 to 1
Haynes	4.07 to 1
Buick	3.77 to 1
Overland 86	4.01 to 1
Overland 83	3.70 to 1
Oakland Eight	4.8 to 1
Oakland Large Six	4.25 to 1
Oakland Small Six	4.42 to 1
Willys-Knight	4 to 1
Chevrolet 490	3.67 to 1
Chevrolet	4 to 1
Chalmers M. 6	3.75 to 1
Chalmers 48	4 to 1
Chalmers 40	4.50 to 1

Ratio Gearing; 1st, 2nd, 3rd and Reverse.

Q.—What is the difference in ratio of gearing on first, second and third, or low, intermediate and high, of a car?

A.—This varies slightly in different cars. The ratio on a King Eight, for instance, is: First or low speed, 14.8 to 1; second or intermediate speed, 8.7 to 1; third or high speed, 4.6 to 1; reverse, 18 to 1. See page 22 for explanation of ratio.

Meaning of 25-35; Engine Rating.

Q.—What does 25-35 horse-power mean? I note many manufacturers rate their engines with two ratings.

A.—The 25 means the horse-power acording to the Society of Automobile Engineers' formula at 1000 r.p.m. The 35 means the actual block test the engine is capable of developing at full speed. It is taken for granted that the engine will develop 25 horse-power continuously, and will stand an overload of 35 horse-power for short periods. Most electric generators will stand a considerable overload for a short period but will heat if run overloaded continuously. The same applies to the automobile engine.

If Brakes Fail Going Down Hill.

Q.—If the brakes failed in going down hill what would be best to do??

A.—In going down hill nine chances out of ten the operator will coast, that is he will throw out his clutch and disconnect the power from the rear axle. His engine naturally is slowed down as no experienced driver would want to hear his engine race. Therefore we have the engine running slow and idle and clutch out coasting.

If a stop was necessary and the brakes failed, then the first thing to do would be to throw off the switch and let in the clutch. This would check the car because the engine would have no power stroke to propel it and the piston on traveling upwards on the compression stroke would encounter a resistance in pressure. This pressure or "held back on compression" mean the same (study the four strokes or four cycle principle) and note what compression means, also study the relation of the clutch to the engine and the drive of the car.

When it is necessary to descend a very steep grade it is best to engage the intermediate or possibly low speed gears before commencing the descent, and if the resistance of the engine thus obtained is not sufficient, supplement it by the foo brake. Bear in mind that the more the resistance of the engine is used in coasting the longer the brake band linings will wear and the brakes retain their adjustment.

When descending a long grade the engine is used as a brake, the switch should be turned off to prevent heating which might occur if the sp k be retarded.

The principle of this method will be understood when you realize that the same combination of gearing which changes the ratio between the engine shaft and the rear axle, which makes it easier for the engine to drive the car, will when the car is compelled to drive the engine, have exactly the opposite effect, which is the case when the above method is used in descending a hill.

Note: If engine stops and brakes fail in climbing a hill, see page 492.

Advisability of using Engine as a Brake Downhill.

Q.—I should be obliged if you will inform me whether it pays to save the brakes when descending a hill and to use the compression of the engine by switching off? Is it not correct to assume that the engine is using as much gas as though it were driving, and is thus wasting fuel? I may say, however, that the brake effect is very good, even with top gear in use. It is only when descending an unusually steep hill that there is any need to use the foot brake.

A.—It can be recommended as good practice to use the engine as a brake, provided that it draws in pure air and not mixture. This is most wasteful, as it is equivalent to having the engine running at full throttle all the time. The correct practice would be to shut the throttle and open an extra air valve which could be provided on the inlet pipe. In this way the engine serves as an economical brake, and prevents wear and tear of the regular brake shoes

If Engine Overheats and Piston Sticks.

Q.—If on acount of overheating a piston becomes "seized" or stuck what is best to do?

A.—See index "Seized piston."

Wire on a Magneto.

Q.—How many feet of wire is used on a low and high tension coil, and what size of wire is used?

A.—There are many thousand feet of No. 36 or No. 42 small silk covered copper wire on a secondary winding, see page 240.

Signs of Punctured Insulation.

Q.—What are the signs of punctured insulation in the high tension winding of a magneto armature, and how would you test?

A.—If the insulation is punctured on the high tension wire winding, the result would be that there would be a weak spark, and finally where insultation was punctured and bare, a spark would very likely jump through to another winding unless the top layer was well insulated, and eventually short circuit and put the armature out of commission altogether; but the first noticeable result would be a very weak spark or no spark at all. See pages 235, 249 and 253, "testing a coil."

Cause of Noise; in Timing and Magneto Gears.

Q.—I have a ——car fitted with magneto ignition run by gears. When engine runs slow or is slowly revolved, these gears seem to kick back and forth and make a lot of noise, what is the cause?

A.—The cause of this is worn gears. Very likely on the magneto side, and this "pull back" as you call it, is occasioned by the pull of the armature of the magneto. If you have ever turned over the armature of a magneto, you know how it jumps at a cerain point, which is caused by the pull of the magnets on the armature.

Now, when engine is running slow, and this point is reached, this is what has a tendency to pull the gears, and if the gears are worn, they will be noisy.

It is advisable to put in a new idler gear, and a new magneto drive gear.

When new gears are fitted, sometimes they make a great deal of humming noise. This noise, can sometimes be taken out by placing oil on the gears and holding "tripolite" on them while they are in motion. (Be sure not to get any tripolite on the bearings.)

The Spark—Why Blue or White.

Q.—Why is it that some coils give a thin blue spark and others a white thick one? I believe it is on account of the winding being burnt in some place or the insulation injured—am I right?

A.—Coils wound for low voltage and large amperage give fat red spark.

The Bosch Magneto Co. describe it as the "arc-flame." Weak or damaged coil will give thin spark, but will not jump a very wide gap.

Sparking Across Safety Spark Gap.

Q.—Why is it that a magneto and coil, sparks across the "safety spark gap" irregularly, when the engine runs slow, but stops when speeded up?

A.—Expansion of surplus gas, causes excess compression through which spark will not jump.

If Battery Gives out on Road.

Q.—If batteries run down and I have no other ignition electric source what would I do?

A.—Try nearest farm house and borrow or buy the telephone batteries.

Magnet Lifting Power.

Q.—Should the magnets of a magneto lift a weight of from 10 to 20 lbs. singly or all together?

A.—If a magnet is hung up and pieces of metal added to it from time to time, it will take on in this way two or three times as much as it would carry if required to lift the load at once. A single magnet will lift from 4 to 6 lbs. in normal condition.

Locking a Car.

Q.—I understand it is not a good idea to lock the wheels of a car in the down-town district, because the fire department might need to move car in case of fire. What method of locking a car would you recommend?

A.—If you have a Ford, use a K. W. ignition switch with Yale lock which can be secured at any supply house. Otherwise, use a secret plug switch, placed where it will not be seen, to open the ignition circuit, or close a padlock on the spark and throttle lever to lock it to the web of the steering wheel. The latter arrangement however, is not altogether practical if there is an accelerator.

Right of Way; Wagon or Auto?

Q.—If an automobile is back of a wagon as the wagon is going the same way, is it necessary or does the law require that the wagon give the auto the road so he can pass?

A.—In the city an ordinance requires all slow moving vehicles to keep to the curb side of the street on the right, and faster vehicles to pass in the center to the left of the slow vehicle. On country roads, section 8 of state automobile laws, provides that anyone driving a motor car who overtakes any horse or animal being ridden or driven, the rider or driver of the animal shall turn to the right side of road to permit free passage on left side.

Right of Way on Cross Streets.

Q.—Which car would you say had the right of way, one coming out of a cross street onto a thoroughfare, or the car on the thoroughfare?

A.—A car coming out of a street to your right has right of way over you, as you have over the car coming out of a street to your left. See chart 218.

Greatest Number of Miles of Road.

Q.—What state has the highest mileage of roads? Are the roads of Missouri being improved?

A.—Kansas has the greatest number of miles of road; 111,586. Missouri comes second with 108,000; Iowa third, with 104,000; Illinois fourth, with 100,000. In 1912 Missouri had the greatest mileage. Out of the 108.000, miles of Missouri roads, 4750 miles are improved, 103,250 miles are dirt roads and 3500 miles are gravel. Missouri made no improvements at all in 1914. Indiana however, spent $17,000,000 in 1914 for improvements; Iowa, $11,000,000; New York, $14,000,000, and very near all other states made improvements costing from $156,000 to $9,800.000

Re-Painting a Radiator.

Q.—Will you suggest a good method for repainting a radiator?

A.—The best plan is to take the radiator to a specialist, who will dip it. If you prefer to do the work yourself, remove the radiator, lay it flat and pour upon it a mixture of lampblack and turpentine made so thin that it will run onto the sides of the cells. Wipe off any of the mixture which may splash on the painted part of the radiator before it dries. At first the color will appear gray, but will soon darken (see page 194 and index.)

Muddy Radiator; Cleaning.

Q.—The front of my radiator is muddy. What is the best plan for clearing it?

A.—When it is necessary to clear the radiator spaces of accumulated mud, you should flush the radiator from the rear, not from the front. In that way you avoid getting water into the magneto or ignition system, which is often short-circuited when the moisture enters it.

Front Axle Bent.

Q.—I bent my front axle, but local blacksmith is afraid to try to bend it back, as he says it was made of special steel.

A.—Axles are usually made of nickel steel. To straighten, heat to a cherry red, then straighten. If heated hotter than a cherry red all the nickle will be taken out of the steel.

Side of Street to Stop on.

Q.—If a tire is blown out and it is necessary to stop, what side of the road would I stop on and leave car?

A.—Obey the traffic law, see rules of the road.

Engine Uses Too Much Oil.

Q.—I have a car that has always used too much cylinder oil. I recently had nonleaking piston rings applied, one in each piston, although the old rings were good and the cylinders were not worn, the tool marks not being effaced. Can you give me a remedy for the oil getting by the piston rings and fouling the spark plugs and valves?

A.—It is possible that the cylinders have been worn out of round or that the pistons fit poorly. A good mechanic should be able to micrometer the pistons and cylinders and determine whether this is the trouble. If the cylinders are in good shape and the pistons fit poorly the remedy is to install oversize pistons. If the cylinders are scored the only remedy is reboring the cylinders and fitting new pistons, see also page 202.

Oil Leaks from Bolt Holes of Crank Case.

Q.—How can I stop the oil from leaking through the bolt holes of the lower crank case cover and out of the fly wheel housing drain plug?

A.—Back the studs out about ¼ inch and wind five or six turns of cotton twine around it between the lock washer and the case cover. This will positively stop the leak through the stud holes. However, we are inclined to think your oil is running down the side of the case from some other point. Perhaps the valve push rods. Wipe all oil off thoroughly and run the engine idle at about 600 or 800 r. p. m. and see for sure where the oil comes from.

Causes of Vibration of Engine.

Q.—About a year ago my engine began to vibrate, at around about 25 miles per hour. It did not vibrate when new, and I would like to know what causes vibration. It operates O.K. outside of that. Bearings are O.K. In fact, it runs just as smooth as when new, except that it vibrates. Will a crank shaft that is out of line or out of balance cause this?

A.—Vibration is due to forces being out of balance or unequal, for instance; engine loose on frame, uneven compression, weak explosion in one or more cylinders, due to leaky rings or valves or too much oil in that particular cylinder

Defective spark or plug. Sprung crank shaft. Clutch out of balance. New full size bearing and shims on one crank throw, and the old worn or lighter bearing with shims or liners removed on the other crank throw. Different weight pistons. Front wheels out of true, rim out of plane with spokes. Would suggest throw-out clutch and run engine idle at different speeds.

How to Determine Correct Carburetor Mixture.

Q.—How do you determine when the carburetion mixture is correct by the color of the flame from the relief cock and what is the cause of so much smoke coming out the exhaust?

A.—See page 169.

Kerosene for Cooling.

Q.—Would kerosene make a good substitute for water for use in radiators of cars during winter?

A.—Objections are the odor of heated kerosene; when heated kerosene evaporates and is liable to cause a fire if near a flame; on warm days in winter there is a tendency for engine to heat on account of difference in co-efficient of heat of kerosene and water or alcohol; kerosene rots radiator tubing and will also deposit a greasy mist over car. Gas is also liable to form and cause expansion and bulging of radiator.

Kerosene and Gasoline.

Q.—Is it possible to use kerosene in the carburetor of an automobile?

A.—Yes, but it is necessary to start on gasoline. Many experiments have been made to determine the possibility of using low-grade fuels like kerosene. They have shown that these fuels can be used under proper conditions, but that it is difficult for the ordinary motor car user to get satisfactory results from them. Gasoline is volatile; kerosene is not. Clogging up or loading up takes place whenever the engine is too cold, after coasting or standing. Often when the engine is throttled the fuel seems to condense, load up the intake pipe and occasionally flow back into the carburetor. When the throttle is then opened this excess fuel is drawn into the cylinders, as shown by clouds of smoke and carbonization results. Kerosene requires some outside heating device to vaporize it. Experimenters are working on this problem of heating and no doubt will succeed in time. "Necessity is the mother of invention," see index.

Gasoline and Kerosene.

Q.—What proportion of gasoline and kerosene will work together?

A.—The proportion of kerosene which can be used with gasoline on some carburetors is 1 gallon of gasoline to 3 gallons of kerosene. But starting will have to be with gasoline. Better have extra tank of gasoline to start on until engine warms up, see index, "kerosene carburetion."

Low Grade Gasoline.

Q.—Is low grade gasoline suitable for automobiles?

A.—The present day gasoline for automobiles, is usually in three grades, called No. 1, 2, and 3. The lowest grade No. 3 is used quite freely, but if its sets for a week unused you will likely find that all the coal oil in the gasoline, which is the heaviest, has settled at bottom of tank and hence difficult starting. If you stir it up or take an oil gun and draw off some from top and put in carburetor to start on it will probably help. See page 161.

Why Engine Runs Smoother at Night.

Q.—I have always noticed that my engine runs smoother or better at night. Why is this?

A.—Experiments with stationary internal combustion engines have shown that water vapor—steam—injected into the combustion chamber gives an advantage, but the reason is not clear. On the same principle an engine runs better at night when there is more moisture in the air. It may be that the additional oxygen supplied by the small amount of water aids in the combustion of the fuel.

Ether and Gasoline.

Q.—What proportion of ether can be used with gasoline to increase power and speed for racing?

A.—See index for ether.

Carburetor Drips.

Q.—When I stop my engine I notice gasoline continually drips from the bottom of carburetor. What causes this?

A.—The float needle valve is probably the cause. Remedy: Put in a new one. To test: Remove carburetor from engine, then test the float needle valve by pouring gasoline into the float chamber. If gasoline drips from needle valve then the trouble is in the needle valve and a new one must be fitted. If it does not drip at needle valve, but comes from the jet, then the float is set too low—slightly raise the float. When refitting carburetor back on engine be sure a tight fit is made where joined to inlet pipe, otherwise an air leak will interfere with carburetion. Leather makes a good gasket for carburetor. See pages 164 and 166.

Leaky Carburetor Float Needle Valve.

Q.—How is a leaky carburetor float needle valve ground to keep it from leaking?

A.—If made of steel use crocus or a fine grade of emery with a little oil and grind the needle to a tight seat. If brass and the needle is tapering lightly tap it with a hammer on its seat, then grind a tight seat, using oil. To test after grinding, pour in gasoline and note whether it drips. A new needle valve is the best. See page 167.

Out of Gasoline on a Country Road.

Q.—If I was in the country and run out of gasoline what would I do to get back?

A.—Send for gasoline if none can be secured at a farm house. If kerosene could be secured in the vicinity, which is more likely than gasoline, then drain tank of what little gasoline is left, unscrew carburetor float top, pour in until carburetor chamber is full. Mix remainder with kerosene and pour into tank. Start engine on the gasoline in carburetor, then when started it ought to run on gasoline and kerosene mixed. The greatest amount of kerosene to gasoline which can be used on the average carburetor is 3 to 1.

Note: this will not work satisfactorily unless intake is heated, see page 157.

Cause of Carburetor Freezing.

Q.—My carburetor froze up during the last cold weather, and I could not start my engine. What causes this?

A.—The presence of an abnormal amount of water in the gasoline is the trouble. Garage proprietors say this trouble was never so pronounced as at present, and they attribute it to the adulteration of oils, believed to be carried on to a greater extent this season than ever before. See page 161.

Gasoline Consumption.

Q.—Does it take more gasoline when running slow and in congested traffic than when running on country roads?

A.—Yes; this fact was demonstrated by a Marmon car recently. In the business district of Chicago ten and one-half miles per gallon was the average, whereas on streets where conditions were similar to country roads the same car did fifteen and three-fourths miles per gallon. Most likely due to the momentum of car in the one case, and absence of it, in the other.

*Freezing and Boiling Point and Specific Gravity of Water, Alcohol, Kerosene and Gasoline.

Constants	Water	Wood Alcohol	Ethyl Alcohol	Denatured Alcohol Formula #1	Kerosene	Gasoline
Freezing Point	+32°F 0°C	−144°F −98°C	−202°F −130°C	−200°F −129°C	Does not have a definite point Solidifies about −50°C	−202°F −130°C
Boiling Point	+212°F +100°C	153°F 67°C	173°F 78.4°C	171°F 77.4°C	387°F 197°C	173°F 78.5°C
Specific Gravity	1.000 at 0/4°C	.789 at 0°C	.8002 at 0°C	.8164 at 15°C	.815 at 15°C	728 at 15°C

---

*Mercury freezes at 38.7° below zero and boils or gives off gas at 357° above zero, Fahrenheit.

Straining Gasoline.

Q.—I noticed an article in some paper recently that by pouring gasoline through a chamois in a funnel, electricity was generated, set fire to the gasoline and severely burned a man pouring the gasoline. Do you think such a thing possible?

A.—So some one claimed, see page 162.

Soldering and Repairing Radiator Leak.

Q.—What kind of tool or torch can be used for repairing radiators? I find it hard to get at the small openings in a radiator with a common soldering iron.

A.—Procure at some electric establishment a heavy piece of copper wire. Hammer it out to fit the place you desire to solder. After soldering, place radiator in a vessel of water. Close up one end of the radiator and plug the other end. Place a small piece of tubing through one of the plugs and pump air into the radiator. Note whether it leaks. If it does, mark the place—scrape and resolder. See pages 191, 194, index.

Will a Clincher Tire fit a Q. D. Rim.

Q.—Will the old-style plain clincher tire fit a quick detachable clincher rim? Also let me know whether a straight-side tire will fit a clincher rim?

A.—Yes, a plain clincher tire will fit a quick detachable clincher rim, but a quick detachable clincher tire will not fit a clincher rim. It may be forced on, but it will be quite a job, and the probabilities are the bead would be damaged. A regular clincher tire has a flexible bead. A quick detachable tire has a hard bead. I have seen a straight side tire on a clincher rim, but it is not practical. See page 558.

Overloading of Carburetor.

Q.—(1) When descending grades with the throttle closed, the engine shows a tendency to overload, and appears to start with difficulty when the throttle is reopened. (2) What is the cause of a decided rumbling noise in the transmission, when the machine is ascending a grade on intermediate gear?

A.—(1) Too much gasoline. Change the low speed adjustment. May be the float is too high, if cutting down the gasoline supply does not remedy the trouble. The engine will pick up sluggish if there is too much gasoline, therefore the adjustment ought to remedy this trouble also. You did not mention the make of the carburetor hence definite directions cannot be given. (2) All second-speed gears make more noise than the high gear. May be worn gears or bearings, or both are responsible.

Metering Pin and Dash Pot.

Q.—I notice the term "metering pin" and "dash pot" used in speaking of carburetors. What are they for? A.—See page 151.

Proportion of Air to Gasoline.

Q.—What proportion of air is used with gasoline in carburetors?

A.—The best explosive mixture when maximum power is desired with the gasoline commonly used is 14 parts of air to one part gasoline. From this the mixture can range to 17 to 1, the latter for maximum economy—see page 142.

Mixture Which Heats.

Q.—What kind of mixture heats engine most, rich or lean?

A.—Lean mixture under load. Rich mixture running light—see page 169.

Different Size Spark Plugs.

Q.—How many sizes of spark plugs are there in general use? Why don't manufacturers use one size plug? A.—See pages 235 to 239.

Spark Plug Points; Correct Distance to Set.

Q.—What is the correct distance apart to set the points of spark plug and interrupter?

A.—See pages 235, 233, 219, 297, 298.

Distance the Spark will Jump.

Q.—If a spark will jump ⅛ to ¼ inch outside of cylinder what space will it jump inside?

A.—The spark which will jump from one-quarter to three eighths of an inch on outside of a cylinder, will jump one-sixteenth of an inch inside under compression, (see page 286). A spark which would jump no further then one-quarter of an inch on the outside of the cylinder has worked, but we would advise that a coil which jumps three-quarters or one inch for general use, because, if you use a low grade gasoline it is harder to ignite than a high grade.

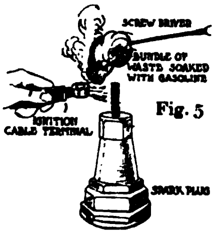


Fig. 5

Substitute for a Match.

A piece of waste or cloth dampened with gasoline is tied to a screw driver. One of the ignition cables to a spark plug is removed and placed near enough to the electrode so that the spark jumps across. The cloth is introduced between the two and the spark will ignite the gasoline.

Engine Continues to Run.

Q.—I use a magneto and battery for ignition. In running on the magneto, when I turn off the switch the engine continues to run. Why is this?

A.—The ground wire from your magneto to the frame of your car is evidently broken. In magneto ignition the switch closes or short circuits the primary winding through this ground wire. Therefore if the ground wire is broken the current could not be short circuited and the engine would continue to run—see page 275 and 276, fig. 1.

Spark Plugs Indicate Condition of Valves.

Q.—Can you tell by the condition of the spark plugs whether the valves need grinding?

A.—Yes, if the end of the spark plug is oily it indicates too much lubricating oil or leaky piston rings. If black soft soot like that which accumulates in a lamp chimney, this indicates that too much gasoline is being fed to the cylinder through intake, causing too rich a mixture. This may come from improper carburetor adjustment or an air leak in intake manifold. If the ends of the plugs are oily and sooty, this would indicate that the valves leak, as this permits burnt gases being drawn into the mixture, which would result in poor combustion and lack of pressure in cylinder, which would permit oil to pass and foul plug.,

Telephone Generator.

Q.—Can I use a telephone generator taken from an old phone for ignition?

A.—No; this generator generates a high voltage, but practically no amperage or quantity of current at all. If you were to run it at high enough speed, say 3000 revolutions per minute, and had a proper transformer or coil to "build up" the current, that is, to reduce the voltage and make a higher amperage, it might be used with the make-and-break system of ignition.

Battery Jar Trouble.

Q.—I have an Exide storage battery which has two cells leaking. Can you inform me what a hard rubber cell may be patched with, in order to stop leakage of acid?

A.—A hard rubber jar cannot be patched. A new jar will be necessary, which can be secured at an Exide storage battery station. A new jar will cost about $1.75.

To Tell (N) and (S) Pole of Magnets.

Q.—How do you tell the north and south poles of magneto magnets?

A.—To tell the positive and negative poles; north pole is positive -|- and south pole is negative —. To find north and south pole; use a compass as explained on page 303.

A "Twin Two" Cylinder Engine.

Q.—Is there any make of car using a four-cylinder "twin two"?

A.—The Leon-Peugeot, a French car, uses this type of motor. There are two cylinder blocks placed 10 degrees apart from the vertical.

Missing on a 2 Cylinder Opposed. Engine.

Q.—I have an I. H. C. Truck, which has a two cylinder opposed type engine. The back cylinder misses fire every two explosions. If I short circuit the front plug and give a little more gas, then it does not miss, but when I let the other cylinder work, it misses.

A.—From this meager information it appears that one cylinder is getting too much air and one too much gas. The one which misses appears to get too much air, either through a worn valve stem guide, a worn stem, or where manifold connects with the cylinder. In the manifold, near the cylinder which does not miss, drill a small hole and put in a pet cock, then gradually let in air to equalize. This cylinder evidently gets the richer mixture and needs air.

How 2 Cylinders on a 6 Work Together.

Q.—Do two cylinders on a six and an eight cylinder engine work together at one time?

A.—Yes, for certain periods of time. See pages 122 to 126.

Laps of Power Strokes on a Twelve.

Q.—Do two cylinders work together all the time on a twelve-cylinder engine?

A.—On a twin six-cylinder (twelve-cylinder engine) there are twelve periods of 14 degrees when three pistons are working together, and twelve periods of 46 degrees when two pistons are working together. This naturally gives steady power or torque. See pages 126, 135 and 136.

Why Racing Engines 4-Cylinder.

Q.—If the eight and twelve cylinder engine gives more flexibility and is considered the coming car, why is it all the racing cars are four cylinder?

A.—Four-cylinder engines are used for racing cars, because there is no advantage in using more, when a smaller number will do the same work. The six, eight and twelve cylinder engines are coming into use because they give more flexibility. You can run a car with a six, eight or twelve cylinder engine at very low speed uphill or in traffic without changing gears. In a race the desideratum is speed, and flexibility which is an essential in the ordinary use of a car, is of no advantage.

Four Cylinder Engine Using 16 Valves.

Q.—Some one told me that there were four-cylinder automobile engines using eight inlet and eight exhaust valves, or two inlets and two exhaust valves to each cylinder. Is this true?

A.—Yes, the Duesenberg four-cylinder engine, which started in the New York speedway races, had sixteen valves, as had also the Wisconsin engine used in the Stutz which won the race. See page 109. The White car also uses sixteen valves.

Diesel Engine Principle.

Q.—What is the principle upon which the Diesel engine is operated? I understand no spark at all is used for ignition. How is the gas fired?

A.—The principle of the "four cycle" type of Diesel engine may be briefly described as follows: On the first or down stroke of the piston the Cylinder is filled with air at the atmospheric temperature and pressure. No fuel is introduced. On the second stroke, the piston travels up and the air, drawn in during the preceding stroke, is compressed to about 500 pounds per square inch, resulting in its temperature being raised to about 1000 degrees Fahrenheit, or sufficient to ignite any liquid fuel. Then the fuel valve opens and a measured quantity of fuel, usually oil, is injected into the cylinder through an atomizer. The atomized fuel is ignited by the high temperature of the air and the power stroke follows. On the fourth or exhaust stroke, the piston travels up and the burnt gas is expelled through the exhaust valve. The Diesel engine requires no ignition system and uses the cheapest of petroleum, crude, fuel oils or tar oils.

Speedometer Gearing.

Q.—Could the same speedometer be used on a 30x2½ tire that is used on a 30x3 tire?

A.—Yes. This will not necessitate a corresponding change in gears. It is only necessary that the number of teeth in the road wheel gear, always be equal to twice the number of inches, in the diameter of the wheel.

Knight Engine, its history.

Q.—Has the Knight engine been tried out fully, or is it still an experiment? What foreign manufacturers use it?

A.—The Knight sleeve valve type was invented in Chicago in 1903. The engine was under experiment until 1905, at which time it was given severe tests in Elyria, Ohio. In 1906 Charles Y. Knight submitted his engine to the largest motor car company of England, the Daimler Company. After tests, the Daimler Company adopted it. Other leading European automobile manufacturers who adopted this type of engine are the Panhard Company, France; Mercedes Company, Germany, and the Minerva Company, Belgium.

Why More Spark Advance on a Six.

Q.—Why does a six-cylinder engine require more spark advance than a four?

A.—It doesn't, if measured on fly wheel. If measured on movement of the distributor brush, it does. Because the distributor brush on a six travels faster than on a four.

Thermal Efficiency.

Q.—What is meant by "thermal efficiency"?

A.—Thermal efficiency is the ratio of work actually done, when expressed in heat units, to the total heat supplied in the fuel that enters the combustion chamber and is always less than 100 per cent.

Why Four Cylinder Engines do not fire 1, 2, 3, 4.

Q.—Could a four-cylinder engine fire, 1, 2, 3, 4? How does the Ford fire?

A.—No, not with the present arrangements of the "throw" of the crank shaft, see pages 116 and 119. The Ford engine fires 1, 2, 4, 3.

Cut Cylinders.

Q.—What is the process for grinding out worn or cut places in cylinder?

A.—If a worn place is in the cylinder, then you must first ascertain if you have thickness enough, or wall to grind or bore or ream the entire cylinder down to the depth of this worn place, and then fit in piston, slightly larger, or large enough to take up this distance, (see instruction 46.)

Fire Truck Engine—How Cooled.

Q.—How does the engine on an automobile fire truck cool itself when the engine is running continuously for long periods with car standing, which is often the case at a fire? My engine would soon get hot and the water in the radiator would steam.

A.—There is a cooling line from the discharge side of the main pump directly into the water manifold. This is a ¾-inch line and is controlled by a gate valve which enables the operator to keep the engine at any desired temperature. An overflow on the radiator allows this cooling water, which amounts to 8 to 10 gallons per minute, to pass off.

Why Valves are Called "Poppet Valves."

Q.—Why are the inlet and exhaust valves on the gasoline engine called "poppet" valves?

A.—The valve is continually popping up and down as the cam turns, which may account for the name "poppet." However, the word poppet probably is a corruption of the name puppet, applied to this type in England, on account of its resemblance to the popping up and down of the puppets in the old-time Punch and Judy shows.

Lynite Pistons.

Q.—I notice "lynite" pistons are being advertised for Ford engines. What is "lynite"? What are the advantages?

A.—Lynite is an aluminum alloy of French origin. It is produced in America by the Aluminum Casting Company of Detroit and Cleveland. Pistons made of this material are one-third the weight of cast-iron pistons. The manufacturers claim greater reciprocating motion, which allows quicker acceleration, less friction and less vibration. The McQuay-Norris Manufacturing Company of St. Louis controls the exclusive sales of Lynite pistons for Ford cars, which are sold in sets.

Annular Ball Bearings.

Q.—I often hear the term "annular" ball bearings. What kind of bearing is this?

A.—Two types of ball bearings are in general use on motor cars, the "annular" and the "cup and cone." Annular means "ring shaped." The balls on an annular bearing move around the center of the inner race. They carry the load radially and do not take care of the thrust lead. The cup and cone type of ball bearing can be adjusted and will carry a thrust load as well as a radial load, see page 86.

Piston Clearance.

Q.—Are pistons fit to cylinders to .002 (two thousandths) part of an inch, if not, what is the difference?

A.—Cast iron pistons are supposed to fit to one-thousandths per inch of piston—for instance, if the piston is 4 inch it would have to fit four thousandths at the top and two and one-half thousandths at the bottom. Pistons heat much more than the cylinder, therefore this is allowed for heat expansion. See index "piston clearance."

Ford Magnets—how placed.

Q.—(1) When the magnets are bolted in flywheel of a Ford magneto, which poles go side by side? (2) Also, when not on flywheel just lying loose, should they have keepers across ends? (3) What weight should one of these magnets lift when fully charged?

A.—(1) N. and S. (2) Yes, by all means. (3) 1¾ to 2 pounds when fully charged.

Old Tires, Price Of.

Q.—What price ought I get for my old tires and tubes?

A.—The average price paid is 5c for old tires and 6c per lb. for tubes.

Grades, How Calculated.

Q.—Would thank you to explain how grades are calculated. How would you determine a grade of 20 per cent?

A.—A grade 1 in 5 equals 20 per cent; a rise of 1 foot in a distance of 5 feet horizontally; 1 foot is 20 per cent of 5. In other words, if the distance traveled is 100 feet in a certain direction and the rise is 20 feet, this would be a 20 per cent grade, see chart 226-A.

Why Not Solid Tires?

Q.—Why can't I put solid rubber tires on my automobile and save tire expense?

A.—Because cars that run above fifteen miles per hour would soon rack to pieces. The vibration would be too great, and while there might be a saving on tires the cost of repairs on the car would be far greater. Solid tires at high speeds are also dangerous, owing to greater tendency to skid.

Undersize Tube.

Q.—Could a 32x3 tube be used in 32x3½ casing?

A.—It is not advisable. An inner tube should fill the casing without being greatly distended. As a rule the so-called "over-size" tubes, such as 33x4, are best for use in casings 32x3½.

Wheels out of Line Cause of Tire Trouble.

Q.—My tire on the front right wheel has worn considerably. The tire man said it was caused by my wheel being out of line. How will I line it up properly?

A.—See chart 279.

Why Right Rear Tire Wears Most.

Q.—I have always heard that the right rear wheel carries more load and hence the tire on this wheel undergoes more wear. Why is this?

A.—This is due to the crowned or oval surface of the road, and because you drive on the right side of the road there is more weight on the right wheels. This causes the right tires to grip the road harder. Hence when brakes are applied suddenly the rear wheels often slide, wearing off the rubber.

Valve Timing of Hupmobile.

Model	In. opens deg. in.	In. closes deg. in.	Ex. opens deg. in.	Ex. closes deg. in.
20....	25 or 3½	35 or 4 15/64	40 or 4 27/32	20 or 2 27/64
K&N..	on top	24 or 3¼	39 or 5 9/32	5 or 1 1/16
32....	25 or 3 9/32	35 or 4 37/64	40 or 5 15/64	20 or 2 39/64

Position for Spark to Occur.

20....3° or ⅜" after top, retarded.
K&N..2" before top, igniter in neutral position.
32....15° after top or 1 3/32", spark retarded.

Skidding.

Q.—I have a great deal of trouble with my car skidding. What is best to do, when one skids, throw on the brake?

A.—To control a skid it requires quick perception of the coming deviation, and prompt action to counteract it. Brakes are usually unsymmetrical in their effects, and putting on the brake usually increases the skid, especially if the power is left on. The first thing needed is to declutch and the next is rapid and intelligent use of the wheel.

Brake Bands, how to clean.

Q.—What plan is best to cause brake bands to hold. Have tightened them, but they still slip?

A.—A syringe full of kerosene squirted on Raybestos brake bands occasionally will help them grip the drum. The kerosene has a tendency to dissolve the oily matter on the bands, leaving the surface clean. Squeaky brakes are also remedied by the use of kerosene.

Frosting Compound.

Q.—Will you suggest a quick method for dimming headlights?

A.—Five cents' worth of epsom salts dissolved in a teacup full of water provides the neatest and most efficient headlight dimmer for automobiles, so far proposed. The solution is used on the inside of the headlight glass, where it is allowed to evaporate. The result is a beautifully frosted lens, the frosting on which lasts for several months.—Scientific American.

Painting Cylinders and Manifolds.

Q.—What can be used for painting cylinders and exhaust pipes, or, in other words, a paint which will resist heat?

A.—You can secure these paints from supply houses. If you prefer mixing it yourself, try the following: For cylinder—8 ounces white lead in oil, 6 ounces boiled linseed oil, 2 ounces turpentine, ½ ounce lamp-black. This will make up about 1 pint. This ought to be sufficient for a six-cylinder engine. If too heavy, thin with turpentine. For the exhaust manifold I know of nothing better than aluminum powder mixed with bronzing liquid, and even this will peel off in time. See page 509.

White Smoke.

Q.—I have an Auburn car, about 1910 model, which has a discharge of white smoke, which comes out of crank case, through the breather pipe. This discharge resembles steam and comes out in puffs like the exhaust from a steam engine. The discharge is irregular, and occurs after engine is warmed up.

A.—Your trouble would appear to be worn or leaky piston rings. They evidently permit oil to pass into the combustion chamber. They also permit the compressed charged to pass from the combustion chamber to crank case of the engine

See page 509 how to make paint for inside and outside of tires.

and thence out the breather pipe. The fact that this occurs more when the engine is warmed up than at any other time is due to the fact that your oil evidently thins down more when it is warm. Therefore it is easier for the oil to pass the ring. I would advise that you have your rings examined, and if not worn, use heavier and better oil. Also examine the valve tappets to see whether they are opening the valves as they should. Also see if your valves are opening and closing properly.

Tires for Electric Vehicles.

Q.—Is there any difference in the rubber casing used on electric cars and those used on gasoline cars? If so, what is the difference?

A.—There is no difference in pneumatic tires used on electric or pleasure cars. Quite a number of the electric vehicles use what is called a "cord tire," which is higher in price and said to be stronger. This is due to the fact that an electric vehicle is much heavier on account of the batteries. Many of the electric vehicles use what is called the "Motz tire" with a cushion effect, and which is a solid tire. Solid tires, however, skid a great deal and are really dangerous to use on any type of high speed pleasure cars.

*Useful and Instructive Hints and Suggestions.

Heavier oil in old cars. The engine of a car that has been run for two or three years will give better delivery of power if you will use heavier oil than was at first intended for it.

Clean it out. The crank case oil reservoir should be occasionally cleaned out by flushing it with kerosene, and churning it up well by running the engine idle for two minutes. Drain oil and kerosene and put in fresh oil, otherwise the kerosene will thin the oil and cause burnt bearings.

Oil for the timer. Pure castor oil makes the best lubricating material to use in the timer.

Dry bearings. One source of insufficient lubrication of bearings is sometimes found to be clogged grooves in the bushings. Sediment will accumulate in the grooves which are intended to carry the lubricating oil, and shut off the supply. An excess of graphite will often produce this effect.

"Loading up." Gasoline leaves the carburetor as a spray of liquid. In the intake manifold it vaporizes and becomes mixed with air. When vaporization does not take place rapidly enough, or when too much gasoline is sprayed into the manifold, the liquid will accumulate on the sides and run back into the carburetor. To get best results the intake manifold should be protected from the cooling effect of the fan, and should be warmed by a by-pass conveyor of heat from the exhaust. When the gasoline in liquid form runs down into the air inlet of the carburetor the mixture will be irregular and uncertain.

A test to locate trouble: When the engine starts hard, and you are uncertain whether the fault is with the ignition or the mixture, open the throttle wide and spin the engine with spark off, then turn on the spark and the engine should start, if the spark is correct, on the first half turn.

To keep glass on windshield free from snow or rain. See foot note—bottom of page 508.

Keeping the engine warm: An ordinary carbon-burning foot-warmer, placed under the hood, will keep the engine warm for hours. A blanket over the hood will help it.

The proper way to prime: There is a "best" way to prime your engine to make it start easy. The priming cups usually furnished on top of the cylinder hold just the right amount of priming fluid to do the work. If more than that amount is placed in the cylinder the mixture may be too rich and the starting be difficult instead of easy. With stop-cocks closed, fill the cups with a priming fluid consisting of half gasoline and half ether, then open cocks and allow the fluid to run down into the cylinders.

To lock your car: A piece of trace chain covered with rubber hose and a good pad lock will lock your car so that it can not be run or drawn away. Put the chain around the frame and between spokes of front wheels. It is also a good security for spare tires.

For gasoline leaks: Hard soap, moulded around a leaking place, will serve well as a temporary repair. Wrapping with tire tape will make it more permanent.

Automobile headache: Ask the druggist to put up a few number one capsules filled with three-fourths acetanalid and one-fourth citrated caffeine. Two of these capsules half an hour apart will relieve almost any headache quickly if the stomach is not full of food. While not harmless in over-doses, two may be taken inside of one hour with perfect safety. Large doses will make the lips look blue, and this effect is to avoided.

Refreshing slumber: Fifteen grains of Trional powder taken in a little sweet milk at bedtime, after a long drive, will give refreshing sleep with no harmful result.

Benzol is a promising motor fuel. It is a by-product of coke. It contains the same elements as gasoline, but the chemical formula is slightly different. In England it is used to great extent for fuel, also for explosives, dyes and chemicals. All gas plants in England are being equipped to produce benzol. It is stated that experiments with the material are being made in the United States.

Cleaning spark plugs: The porcelain of a spark plug may be made clean and almost equal to new by soaking it in carbon disulphide. (also see page 592.)

Burning out the coil: When the spark gap of a plug is too great there is danger of burning out the secondary wire of the coil from the heat, due to great resistance.

A spark plug should not be so tight a fit in the cylinder that it cannot be screwed in with the fingers for at least two-thirds of the thread. Otherwise there is a risk of a cross-thread or badly-cut thread jamming tight.

The threads of sparking plugs, valve port caps, and exhaust pipe connections should occasionally be brushed over with some powdered graphite. This prevents seizing or binding of the threads from the oxidizing action of the hot gases.

Wire efficiency: Ignition wire efficiency is not always determined by the thickness of the insulation. This is particularly true of secondary wires. It is, of course, true that insulation should be of good quality, but unnecessary thickness increases the static capacity, a condition to be avoided.

Corroded battery terminals: A little hard grease on the thumb nuts that make the battery connections, will prevent their seizing from acid corrosion.

An emergency: Nine miles from town the dry cells exhausted so that they would not start the engine. I borrowed the telephone cells of a near-by house, started the engine, and returned the cells while engine was running idle.

Dry cells in winter: If you use five dry cells in summer for starting purposes, you had better couple up seven for winter use, as the cold renders dry cells less efficient.

---

*See page 524 for some of the Questions sometimes asked by the State Examining Board and Instruction 46A to 46D for Useful Devices for the Repair Shop and Repair Shop Hints and Suggestions

Storage battery connections: Often the unsatisfactory service of a storage battery is due to imperfect connections. Where the battery is kept in a steel box great care is needed to keep the terminals from touching the metal when the lid is closed. Even an occasional touch when the battery is jarred will run the current down rapidly. The connections should be wrapped well with tire tape, and the metal box kept away by packing with rubber. An old inner' tube makes the best packing.

Adjusting electric bulbs:. If the bulb is not pushed far enough back there will be a dark, round shadow in the middle of the bright light in the road ahead.

Good connections: There should be just as few wire connections as possible in wiring for electric lights or starting purposes. And these few should be made secure against rattling loose by soldering.

The "master vibrator." When a master vibrator is attached to a regular coil it not only serves to equalize the spark supply to all the cylinders, but it also adds extra condensing power to the current, giving a hotter spark.

To test the firing of the cylinders independently, the plug cables should not be held too far from plug, as this throws a severe strain on the insulation of the coil.

It always saves time in investigating for causes of misfiring to try the effect of a new set of plugs, because, in the majority of cases nowadays, any persistent misfiring is due to a spark-plug defect.

Sticking tires: Make the surfaces of rim smooth with emery cloth, apply graphite to the rim, and beads of the tire, and your tire will never stick.

To get out of deep mud: Wrap your tire chains bodily around the tire and rim of wheel so as to make a big bunch, fastening it on with strap or wire; turn on slow gear carefully; go slowly.

Over-sized tire chains: Tire chains intended for wheels larger than your own will, when cut lown to fit in length, give you extra service and atisfaction.

Against skidding: A wise driver will straddle he ridge in the middle of a "greasy" road, or ceep one wheel in a wheel rut, to prevent skidding.

Putting muddy chains away: Hang them to some convenient support, such as the bow rests at rear of car, and, with both hands, hold the bag open and slip it up over the chain.

A good place to carry chains: A shallow box fastened under the bootboards of the tonneau, having several half-inch holes in the bottom, makes a good place for tire chains. Put them in with the mud on, and as it dries it will shake off the chains and through the holes.

Quick tire destruction: A good way to spoil a tire casing quickly is to start your car with a lunge, and stop it with a sudden application of the brakes.

Size of inner tubes: Some manufacturers of inner tubes economize in material by making the tube smaller than it should be for the casing which it is to fill. An inner tube should fill the casing without being distended more than a very little. I find that as a rule the so-called "over-size" tubes, such as 33x4 are best for use in casings 32x3½.

Why is a blow out? When outside wear or inside break in the fabric due to bruises produces a comparatively weak place in a casing, the inside pressure causes a bulge in the location of the weak spot, and this part is then exposed to more wear in travel than the sound parts of the casing. Of course the blow-out quickly follows. Strong inter-liners prevent this bulging, making a slight depression at the worn spot in place of a bulge, and thus preventing excessive wear on the weak portion of the casing.

Great tire mileage: The difference between the tire mileage of different drivers depends quite largely upon the care used to avoid sharp substances in the road. A small, sharp-cornered stone will often make a break in the fabric, and a broken beer bottle will sometimes cut a fearful gash. Tire wear also increases in a fourfold ratio compared with speed. Almost any old tire will run ten thousand miles if carefully favored.

Surprised at the bill: It is quite common for a patron to be surprised at the size of a repair bill, and to go away "sore." This causes him to shun the shop in the future, and also to tell his friends that the repairman is unfair. It would be better policy if an estimated price could be given for the work before taking the job.

The price to charge for work: When a shop is completely equipped with labor-saving tools and conveniences, the patron should pay seventy-five cents per hour for mechanical labor. When not so equipped, a large amount of time is wasted as a consequence, and the patron should not be asked to pay for wasted time.

Preserve the varnish: Ordinary mud, when allowed to dry on, will dim the luster of the best varnish. Rinse it off with a gentle flow before it becomes dry.

Stale gasoline: After standing for many days, even in a tight tank, gasoline will become dead and slow to ignite: It is partly due to evaporation, and partly to chemical changes that take place.

Fender cleaner: Equal parts of turpentine and wood alcohol make a good cleaning proparation for fenders and hoods.

Varnish in a common barn: The varnished surfaces of an automobile body will not remain lustrous very long if the car is kept in a barn where there is manure. The nitrogen compounds given off from manure will soon tarnish and destroy the best varnish.

A slouchy back curtain: A small stick of length equal to the width of the curtain, upon which the back curtain is snugly rolled, gives a neat appearance. Otherwise it will hang in baggy masses.

Putting in a back window: After cutting the celluloid to proper size and shape fasten it temporarily in place by pushing pins through at each corner. Then button the curtain taut, and with a second person on the inside to pass the needle through outwardly, sew it in place, using the original needle holes as far as possible.

A convenient receptacle: By cutting out a square in the floor of the tonneau and attaching a proper sized box underneath you can have a very convenient carrying receptacle in space that is not otherwise taken up. It makes a good place to put a carbon foot-warmer in winter, and may be used for tools and jack at other times.

Vibration and rattle: A soft leather washer placed between two iron washers will often serve to stop the rattle of fenders and brace rods.

Silence and easy riding: An occasional lubrication of the inter-leaf contact parts of the springs will quite materially increase easy-riding quality of a car, as well as eliminate noise.

Friction noises: Wherever two surfaces rub together making a squeaking noise, graphite grease makes the best remedy. Oil in such places is but a temporary makeshift.

Back lash: Non-reversible steering gears usually have a certain amount of back lash to allow the wheels to follow ruts without side resistance on the tires.

Keep radiator full: When the cooling fluid is kept in motion by thermo-syphon action it is quite important that the radiator be kept reasonably full in order that there be a back resistance to aid in forcing the water forward. It is good engine care to frequently add a little cold water, instead of waiting for the engine to knock for water, especially in summer.

To get a locked car home: When the drive wheels are locked from breakage in the differential or the universal joint you can haul the car home by removing the keys that hold the rear wheels to the axles (if a Ford) and allow them to turn freely. Be sure to grease them well.

That harsh, grating sound: When an amateur driver shifts his gear, the excess of sound makes an expert smile. **To shift gears noiselessly, release the clutch to its fullest extent,** then push the change gear lever with a quick jabby motion until the gears go in. Do not slowly push the lever into position. This causes the teeth of the gear wheels to strike and be thrown back, and each approach repeats the noise. The expert endeavors to secure co-ordinate speed of the gears before trying to throw them into mesh.

Water which comes from a chalky district should preferably not be used in the water-circulation system, because this results in deposits of lime forming in the pipe and radiator. Distilled water or well-filtered rain-water should be used.

A test for worn piston rings: When there is an escape back past the piston rings of hot gases the crank case will get warm. When the escape is past the valves this is not found.

To start engine if starting crank is lost or starter fails to work: Jack rear wheel, let clutch in place gears in "high" and turn the wheel. Or let clutch in and have some one push car until engine starts and quickly throw out clutch when engine starts.

A test for trueness: Upon examining crank shaft or connecting rod bearings if you find that they are worn a little more at the ends than in the middle, it means that the crank shaft is not quite true.

Tight bearings: When the removal of a shim makes the bearing too tight for free use, a piece of manilla paper in place of the shim will often give corect adjustment, and will permit a slight tightening if needed subsequently.

To loosen sticking wheel: When a wheel on a taper axle sticks, and you haven't any wheel puller, here is a way to loosen it: Run the nut off entirely, and then run it on again with the castellated end toward the wheel. True the other end of the nut up flush with the axle, letting the wheel down onto the ground from the jack. Hit the nut three or four good cracks with the hammer and the wheel will start every time.

Loose rear wheels: It is wise occasionally to examine the rear wheels for slack. A little wobble on the axle will soon wear the key or key-seat into a dangerous wheel condition.

Broken balls are first indicated by a "clicking" sound. If not promptly remedied entire bearing will be ruined.

Knocks are expensive: At the end of the first two thousand miles the average automobile will require slight tightening up of the crank shaft and connecting rod bearings. To allow small knocks to go uncared for will result in great damage to the parts very soon.

A good carbon remover: Denatured alcohol, squirted into the cylinders when they are hot, and the engine run fairly fast for two minutes, will clean out the carbon.

Adjust your foot brake: Push the pedal forward about two inches and retain it in place with a small block of wood. Now tighten up the turn-buckle until the brakes are snug, and when the block of wood is removed the slack will be correct.

Broken piston rings: Will make themselves known by decreased compression, and by an excessive amount of oil in the combustion chamber and on the spark plugs.

Use split washers: Where castellated nuts and cotter pins are not supplied in automobile construction, good, well-tempered lock washers may be placed under the nuts or the heads of bolts, to keep them from rattling loose.

Impulse air pump—don't run it fast, and don't connect the hose to tire valve, until pump has made a few strokes.

A small magnet is a time saver for picking up screw and other small parts that have dropped into the mud pan. Often the trouble of taking the pan off will be avoided. An ordinary horseshoe magnet, purchasable at any hardware store, may be used.

Where a pump is used to circulate the cooling water it is wise to fill the radiator to the top and then turn the engine over several times, so as to insure the water reaching and filling all parts of the system. If the engine is not turned the pump is an obstruction to the passage of the water into the jackets, which remain partly empty or fill so slowly as to leave the impression that there is more water in the system than there actually is.

In order to clean the inner lining of a top and to remove stains, gasoline should not be used. The best method is to lift the top off, and, after inverting, clean the surface thoroughly with pure soap and water. If gasoline or other quick-acting fluids are used the waterproof of the fabric will be destroyed.

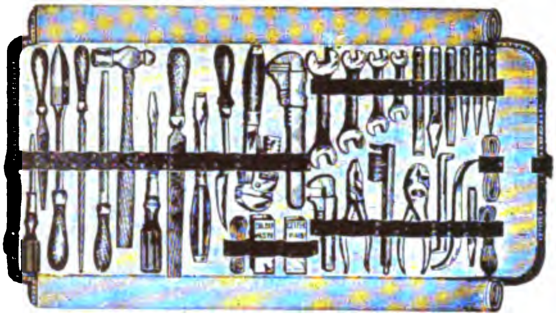
A disagreeable rattle can often be traced to the hood where it rests on its seat. Strips of rawhide or other anti-friction material should be installed to prevent any squeaks or rattle.

Although French chalk placed between a tube and the shoe is very desirable to prevent adhesion, too much of it may prove as bad or worse than none. If too much is used it is likely to work up into little balls, when the continual rubbing and rolling around will ruin a tube in short order and make it almost beyond repair scarcely worth the cost of the work.

To tune a car up for slow race or slow running on high: Probably the engine which runs the slowest and the car which is geared the lowest will be the winner. We will assume that the race will be only on the high gear. By retarding the spark this will also assist in reducing the speed of the engine, but if run too long with retarded spark, engine will heat. The timing of the valves could also be changed by setting the valves to open and close just a little late.

If one prefers to have his engine adjusted to run slow on high, to best advantage, the valves can be adjusted accordingly, but the speed will be sacrificed.

"Dont's" for drivers: Don't drive a car until you are old enough to have good ordinary "horse" sense. Don't look around when your hat blows off. Don't try to kiss the lady in the seat beside you. Don't go to sleep while driving. Don't trust one hand to do the guiding. Don't try to make up lost time by speeding down hill. Don't run at night without lamps. Don't delay putting on the chains when the roads get greasy. Don't forget to "STOP, LOOK and LISTEN" before crossing a railway track—Safety First, Last, and all the time.



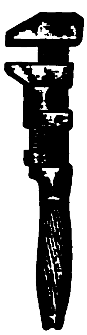
A Well Assorted Repair Kit.

6⅞-Inch Drop Forged Hardened Wrench.
5⅞-Inch Drop Forged Hardened Wrench.
4⅞-Inch Drop Forged Hardened Wrench.
4-Inch Drop Forged Hardened Wrench.
4½-Inch Warding File with handle.
8-Inch Square File with handle.
8-Inch Flat File with handle.
7-Inch Round File with handle.
5-Inch Square Shank Screwdriver, polished.
Machinists' All Steel Heavy Screwdriver.
½-Pound Soldering Iron with handle.
6-Inch Side Cutting Pliers.

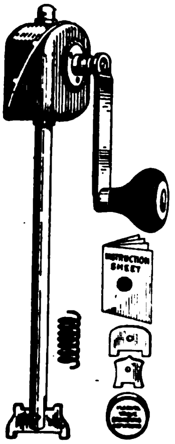
Spark Plug Brush.
⅝-Inch Cold Chisel.
Bundle Wire Solder.
Bundle No. 15 Copper Wire.
Bundle No. 20 Copper Wire.
5-Inch Bicycle Wrench, nickeled.

¼-Inch Cape Chisel.
⅜-Inch Solid Punch, 3-32-inch point.
⅜-Inch Solid Punch, 3-16-inch point.
⅜-Inch Solid Punch, ¼-inch point.
3-Inch Electricians' Screwdriver.

6-Inch Adjustable Combination Pliers, nickeled.
Machinists' Bearing Scraper.
9-Inch Auto Monkey Wrench.
10-Inch Stillson Wrench.
8-Ounce Machinists' Hammer.
⅜-Inch Cotter Pin Extractor, polished.
⅜-Inch Center Punch.
½-Inch Cold Chisel.
Box Solder Paste.
Box Cotter Pins.
6-Inch Offset Screwdriver.

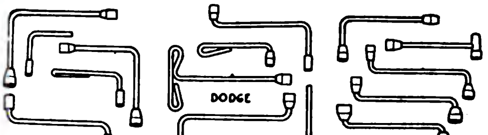


A long 18 or 21 inch **monkey wrench for removing valve caps, hub caps, etc.**

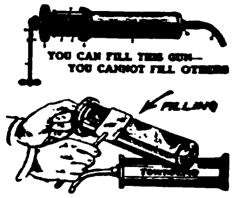


Marvel universal valve grinder—turn the handle in one direction and the valve turns back and forth, always a little further in one direction than the other, eliminating any possibility of leaving rings and ridges. (Marvel Accessories Co., Cleveland, O.)

A good jack is a necessity. Mfgd. by E. V. Hartford, Jersey City, N. J.



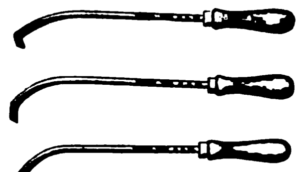
Walden socket wrenches come in sets for various cars and are accurately made to fit the nuts on each car



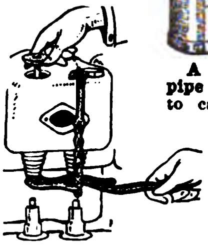
A good grease gun.

Oil Gun

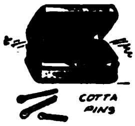
A flat type of blow pipe torch is handy to carry about.

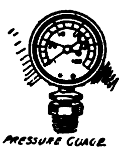


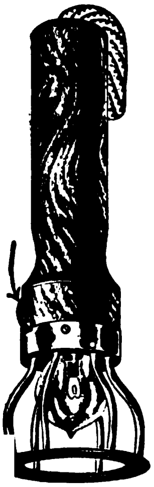
Carbon Scrapers



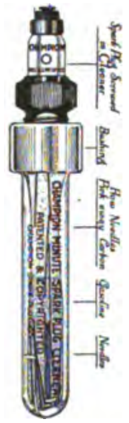
A valve spring lifter saves time and is necessary.



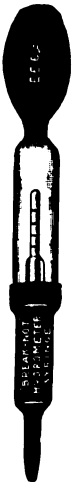




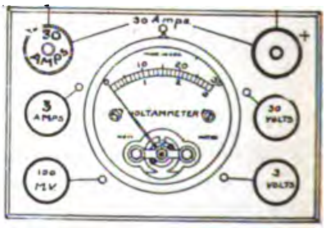
Electric trouble hand lamp.


Spark Plug Screwed in Cleaner
Bushing
Fine Needles Flick away Carbon
Gasoline
Needles
CHAMPION MINUTE SPARK PLUG CLEANER

The Champion spark plug cleaner: consists of a glass tube and steel wires. Fill ⅓ full of gasoline and shake—the spark plug is screwed into glass part.



Hydrometer for testing storage batteries.



The Hoyt rotary meter—for general repair use: for testing out batteries; lamp loads; charge going to battery; to measure line voltage; current taken by starting motor, etc. Price $25.00—Address A. L. Dyke, Elect. Dept., St. Louis.

ART NO. 242—Suggestions for an Auto Mechanician's Outfit—for doing work at homes of auto **or elsewhere—see text for other tools.**

Gauge (as per chart 253A) is also advised.

INSTRUCTION No. 44.

THE AUTOMOBILE REPAIRMAN: Starting into the Auto Repair Business. The Auto Mechanician. Parts to Overhaul on a Car and Engine. Prices Usually Charged for Repair Work. Tools for the Auto Mechanician.

Starting in the Repair Business.

The auto repairman must know how to adjust any part of the car. To know how to adjust, he must first know the principle of the construction of the parts as explained in previous Instructions, and must know when and where to look for trouble. (See digest of troubles; Instruction No. 43.)

About one-half of the work of the automobile repairman is in making adjustments and fitting parts; such as carburetor adjustments, cleaning carbon, grinding valves, fitting horns, muffler cut outs, diagnosing troubles and numerous other little details, which does not require a machine shop, but does require a good assortment of tools, and a knowledge of the principle of the construction of a car.

A machine shop is not necessary, unless there is sufficient work to keep more than **one machinist** busy. A great number of **small** repair shops put in only the tools needed for the average repair work, and when they have a job of machine work to do, they take it to a machine shop. In other words, a machinist and an auto repairman follow two different trades. The **auto** repairman need not be a machinist; I mean by machinist, one who can turn all kinds of metal parts on a lathe and do actual machine work. Therefore, we will explain only the work the average auto repairman is called upon to do.

A Few Pointers for the Beginner.

When beginning work on a car or engine, remember **system** and **order** are two **things** every repairman ought to learn early, they mean success.

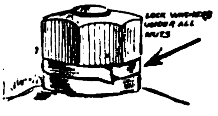
Don't throw nuts or bolts on the floor. Place them in a box or pan.

There is nothing more disgusting to a **man who owns a car, than to walk into a** repair shop and find a careless workman dumping nuts, bolts, etc., here and there on the floor. That customer will say to himself; if that workman is as careless as that, he is careless enough to leave a nut in my crank case and ruin my engine when it is started up, or he will leave off lock nuts or lock washers and cause me expense and damage.

A little piece of metal, such as a piece of a cotter pin or the like, accidentally dropped into a can of grease or oil and subsequently put into the gear case of a motor car has been known to cause much damage, and give the driver or owner of the car considerable trouble and expense.

A Careful Workman the One in Demand.

If you do your work thoroughly and carefully and always do a little more than you agree to do, you will be sure to make **a success.**


LOCK WASHERS UNDER ALL NUTS

Before turning car over to customer be sure that all nuts have lock washers and are tight.

It's the careful man the auto owner wants to handle his car; not the fellow he can't depend upon. I will give you an example of a careless young man who lost his job. An auto owner had a young man overhauling his car; he told him to fill all the grease cups and be sure and see if the valve under the gasoline tank was tight; he had an idea it was leaking. He went away and when he came back that afternoon he asked the young man if he had attended to the different things he told him to do; he said yes. Next day the auto owner was out on a country road and ran out of gasoline. He found that the young man had not examined the valve carefully and the leak had exhausted the tank—the valve was in a difficult place to get at under the car, so he simply took it for granted that it was all-right and let it go at that; so you see a careless man is worse than none at all—it's the dependable fellow who will win.

Don't Overcharge.

We want to warn you that in the matter of charges, it pays to be liberal. Automobile repairmen like plumbers, generally have a reputation for exorbitant charges. Make it a rule to do a little more than you agree to. It is well to comment on your work in talking with the auto owner, like this: "I noticed that some of the nuts were loose around the springs, so I went over all the nuts on the running gear and found that many needed attention. You want to watch those little things, and then you won't need me so often." The owner may not say anything out loud but he will certainly comment to himself, "there's a good repairman," and that is the most profitable reputation you can establish.

You are building a business for the future when you do your work right and treat your customers fair.

---

*The Repair subject has peen divided into several instructions. A study of the headings of Instructions 44, 45 and 46 A, B, C and D will give the subjects treated.

The Automobile Repairman and Mechanician.

We will classify the automobile repair work into two classes: first, will be the automobile repairman who works in a shop under a foreman. His work is laid out for him and he is advised just what to do.

The second, is the automobile mechanician whom we will class as an expert; he will generally be found in the position of a foreman, or operating his own shop. We also find him doing work at the homes of automobile owners.

For the sake of classification and names to distinguish this latter class of work, suppose we call the "auto mechanician" the one who makes a specialty of doing work at the home of automobile owners, in the auto owners private garage.

The Auto Mechanician—how to start.

Many men have found this work profitable and it has been the stepping stone for a future. This work also applies to marine engine and stationary gasoline engine work.

In order to successfully engage in this work, it is necessary for him to provide himself with the necessary tools to do the average work around a car.

I dare say that nine cars out of ten need greasing; that is, the gears, differential, wheels and universal joints. This job is one that does not appeal to the auto owner and the chances are he is not prepared to grease his car if he wanted to. It's easy enough to put grease in the compression cups and screw them down, but to grease the rear axle parts and universal joints, that is a different job unless he is supplied with the proper tool. The auto repairman with the Townsend grease gun, as shown in chart 242, can do the job quickly and easily.

Then there are the valves to grind, carbon to clean out, lost motion in the valves to take up, compression to test—in fact, a general engine overhaul or a general car overhaul would constitute the work that the auto mechanician could do on these special jobs.

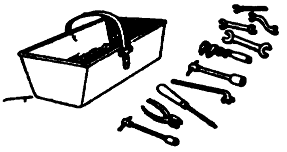
We have illustrated in chart 242 a good equipment for the auto mechanician who proposes to do this class of work.

Very likely when the auto mechanician goes to an auto owner's home to do repair work he will be provided with most material, such as oil, grease, waste, etc., but it is advisable to suggest a good oil and request that the car be supplied with it, providing the oil in use causes a great deal of carbon. In other words, it will be necessary for the mechanician to be able to diagnose all troubles and suggest their remedy, as well as make adjustment and overhaul the car.

Auto Mechanician's Outfit.

Is shown in chart 242, which is suitable for general work around a car, testing etc.

The average workman carries more tools than are necessary to the job, and often finds that even then he does not have the right one. A careful study of the cars handled usually shows that 12 of the common tools will serve to do the ordinary job. It has been found that the following tools are most essential, and are adequate for most jobs: Four open end wrenches, Nos. 34, 25, 29, 734; 1 monkey wrench; 1 main bearing wrench; 1 connecting rod wrench; 1 screw driver; 1 pair pliers; 1 valve cap wrench.



Keep your tools in a box or kit.

Don'ts For The Repairman.

1—Lay wrenches, hammers, chisels, etc., on the fenders or on the seat cushions. Cover the fenders, and remove the cushions during the work.

2—Spill oil, or smear grease over the finish or upholstery.

3—Try to squeeze one car past another in the shop, even though the fenders will spring enough to let the car pass.

4—Pound the end of a shaft with a bare hammer. Use a babbitt hammer, or deaden the blow with a piece of brass or wood.

5—Push a car around the shop, with greasy hands on the varnished surfaces. Either wipe your hands or place a piece of dry waste between your hands and the car.

6—Leave a car standing in a pool of grease.

8—Use an 18-in. Stillson on a ⅝-inch nut.

9—Sit on the cushions with your greasy overalls. Spread a newspaper over them first, and don't put your greasy hands on doors, body, hood, etc.

10—Use his gasoline just because its handier than to get some from store room.

A Car Overhaul.

The following enumerated list gives a detail of procedure in giving a car a general overhauling. Where the automobile owner keeps his car at home and cares for it himself, nine chances out of ten his car and engine needs cleaning, greasing, valves ground, or carbon removed. All of the work mentioned below can be done in the auto owners private garage. This work then would require but a few well selected tools and chances are the auto owner would have most of them. Supplies such as oil, waste, etc. would be furnished by the auto owner. This class of work is well suited for the beginner or auto mechanician.

Cleaning Engine.

1—Clean engine outside with gasoline (see index "Cleaning Engine.")
2—Clean engine inside with kerosene.
3—Clean drip pan.
4—Clean and pack pumps.
5—Clean and adjust spark plugs.
6—Clean the gasoline strainer.

**See chart 100. Also pages 203 and 205.

Lubricating Engine.

7—Put fresh oil into engine after cleaning (see instruction 46).
8—Oil other parts of engine, as magneto, starter, generator, fan, etc.
9—Screw down on all grease cups and refill.

Cleaning Car.

10—Wash car (see page 507.)
11—Polish body with body polish (see page 508).
12—Clean clutch.
13—Clean transmission and underneath car.
14—Clean steering device.

**Lubricating Car.

15—Screw down all grease cups and refill.
16—Grease clutch shaft.
17—Grease universal joints.
18—Fill transmission with lubricants.
19—Fill differential housing.
20—Grease steering device.
21—Grease front wheels.
22—Lubricate the springs.

Inspection and Adjustment.

23—Inspect all nuts and tighten.
24—Inspect gasoline line and tighten all joints.
25—Inspect the balls of front wheels when greasing to see if there are any broken balls. Jack wheel and listen for a clicking sound.
26—Inspect and tighten all loose water connections.
27—Inspect the tires and see if properly inflated.
28—Inspect the steering device and connections and tighten and grease.
29—Inspect the springs and fenders and nuts, tighten and remove squeaks.
30—Inspect rear wheels, see if loose, if so draw up on the nut.
31—Inspect the differential, if noisy, take up lost motion.
32—Examine brakes, if loose adjust them, also tighten spring bolts, nuts and spring clips.

Inspection of Engine and Parts.

33—Inspect water hose on engine and replace with new hose if required.
34—Inspect gaskets on engine and draw up on cylinder head.
35—Inspect bolts and nuts holding cylinder to crank case and tighten.
36—Inspect all nuts and tighten on crank case.
37—Inspect generator adjustment and draw up nuts.
38—Inspect the nuts holding exhaust and inlet manifold and tighten.
39—Inspect for air leaks at carburetor, manifolds, spark plugs. If a leak engine will not idle properly.
40—Inspect all nuts and cotter pins and tighten.
41—See that lock washers are under all nuts.
42—Inspect the muffler and clean if necessary and tighten up.
43—Inspect the timer or magneto and see if connections thereto are tight.
44—Inspect horn, magneto, switch, generator, starter and battery and coil connections, see if there are any loose binding posts or connections. Don't forget to tighten all ground connections.
45—Inspect battery, see if all terminals are tight.
46—Inspect and test the storage battery with a hydrometer (chart 204).
47—Inspect starting motor and generator to see if there are loose connections.

*Engine Adjusting.

48—Test compression.
49—Clean carbon from cylinders.
50—Grind valves.
51—Adjust valve clearance.
52—Test for weak exhaust springs.
53—Test engine for knocks.
54—Take up on any loose bearings.
55—Fit piston rings if necessary.
56—Check up the valve timing (see page 110).
57—Clean and adjust spark plug gap.†

Prices Usually Charged for Car Overhaul.

The price usually charged is from 50 to 75c per hour. Quite a number make a flat price, for instance, after handling a few jobs, the work would come easier and systematic and you could then make a flat price of say $25 for overhauling and cleaning a Ford. (see Ford Instruction.)

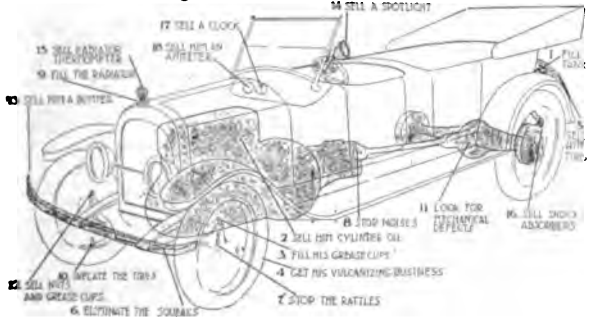
To give an idea for charges where you must make a flat price and where only certain parts of the list are used we give the following scale.

Carbon removed, per cylinder......50c to	$ 1.00
Cleaning and adjusting spark plugs......	.75
Oiling and greasing car	1.50
Cleaning car and polishing..............	1.50
Cleaning engine and drip pan...........	.75
Tightening loose nuts and cotter pins.....	.75
Tightening water and gasoline line.......	.40
Adjusting carburetor and valve tappets and tuning up engine	2.00
Grinding valves ....5 to	10.00

Sell Supplies.

When the motorist drives up to your garage for gas or oil, or air for his tires, give his car the quick once-over and see if you can't sell him some accessories. Here are the places you should look: First fill his tank, then ask if he wants oil, then fill his grease cups, and so on. After you have done one thing, turn to the next.

When a motorist asks for an accessory, this should suggest something else that you can sell him. But it's not enough to ask him if he wants it. You've got to tell him why he ought to have it. That's what these selling arguments are for. Use them!

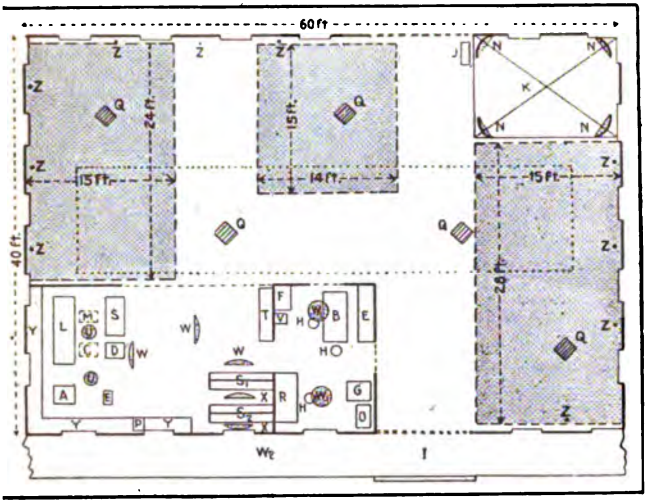


This illustration gives a brief list of merchandise or auto supplies, etc., which the garage dealer ought to sell to his customers. The illustration is taken from Motor World which is intended to be kept in front of the dealer in order that he memorize the list.

Most sales of accessories are lost for the want of a word. Every car owner needs something, and a quick glance over the car—thorough and systematic—will reveal what it is.

**See below for usual charges, and page 574 for charges for tire repair work. †See page 542.

*Explained in Instruction 46.



ʼig. 1—Floor plan of the garage, showing location of departments, skylight and arrangement of tools and lamps

Fig. 1.—Garage.

This garage is designed with a view to economy.

This garage is a one story brick building, 60 by 40 feet, with the longer side toward the street; the interior height is 14 feet from floor to roof, and the latter is carried on trusses 40 feet long and spaced 8 feet apart.

A skylight 10 feet wide and 50 feet long with windows, illuminates the garage during daytime.

Near the middle of the street side (1), 15 feet from one end, is located the main door, which is 10 feet wide. Entering through this door a row of four automobiles is arranged at the right, while at the left is the entrance to the garage office. Adjacent to the office door a board 3 by 3 feet is hung on the wall, on which checking forms, which constitute a part of the garage system, are kept.

The office is 10 feet wide and 15 feet deep, and besides the entrance mentioned, has one door leading into the repair shop and another into the garage proper, which has a floor space of 1275 square feet.

The space filled by automobiles is shown by shading, and there is enough room to accommodate nine ars of 124 inches wheel base and standard tread. The space between the dotted portions illustrate the assageway for automobiles driving to or from their assigned positions in the garage. From the garage roper a 10-foot door leads into the back yard, and adjacent to this door the washrack and charging out- t are located.

The wash-rack is formed by a rectangle deepening toward its center, whence a pipe for the flushing rater leads to the sewer, or other drainage system. The water is supplied either through the medium f ready-made car washer, or through one which can be readily made from ¾-inch standard pipe, a tuffing box, four elbows and about 12 feet of ¾-inch water hose, at a cost of less than $8. The method f assembling the parts is shown in fig. 5, chart 246.

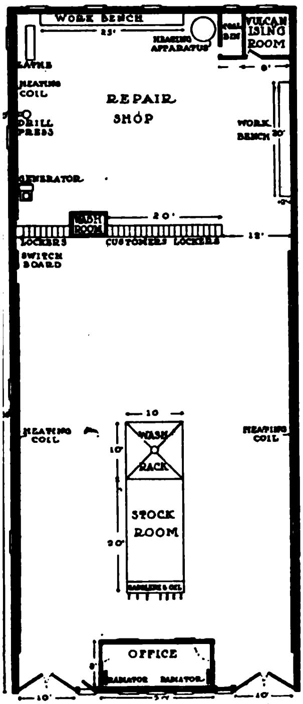


FIG 8—PLAN FOR GARAGE IN SMALL TOWN

The repair shop in this small 9 car capacity garage is but 24 feet long and 15 feet deep, and, besides the door connecting it with the office, has a sliding door between it and the garage proper. This door is sufficiently wide to permit of an automobile being passed through it into the shop, which also contains a small stock of raw material and repair parts stored in shelves S1 and S2, and a tool shelf T.

Fig. 8.—Garage.

Another arrangement and equipment of a garage and repair shop suitable for a town of 3,000 population with good transient and country trade. The size of the building to be 50 by 120 feet, one-story brick or cement block, with the repair shop 40 by 50 feet at the rear.

Fig. 8 shows a garage which would suit the requirements stated beside being convenient and cheaply maintained. It allows of cars entering at one side and leaving at the other, thus avoiding any congestion in getting in and out. Gasoline and oil are handy to the street, besides being under the direct scrutiny of the office.

Posts should be barred and the roof supported by trusses, making the working space much more valuable and saving many accidents to lamps, fenders and varnish. Heat is supplied by a hot-water apparatus located in the repair shop. It is of the overhead supply type—that is, the supply veins extend from the boiler at the ceiling height and branches drop down to the coils and radiators and return just above or under the floor. Steam could be used, but the boiler would have to be sunk considerably in a pit before this could be used at all successfully.

A small gasoline-electric generator set with suitable switchboard is suggested for electric charging and running the lathe and drill-press in case the local service is not direct current. Sky or other kinds of roof lights are a necessity if the garage is on an inside lot and are desirable in any case to make things cheerful and airy and attractive to transients who use it.

Average space to allow for storage of cars; 7 feet is the usual width. The length varies from 13 to 18 feet according to length of cars stored.

ART NO. 243—Two Plans for a Garage for a Small Town: 60x40 feet and 50x120 feet.
tor Age.)

INSTRUCTION No. 45.

BUILDING AND EQUIPMENT OF GARAGE AND SHOP and Approximate Cost. Layout for a small Garage and Repair Shop. Heating and Lighting a Garage. Tools, Machinery. Money Making Additions. Appliances and Useful Devices. How to Build a Home Garage. S. A. E. & U. S. S. Wrench Sizes.

Many, after starting in a small way, by doing work at homes of automobile owners, soon earn enough to start up a shop of their own. We will now lay out a procedure for starting a shop or garage.

A garage is a place where cars are stored and cared for. Most garages also have shops in connection.

If only a shop for repairing automobiles is planned, then figure enough room to take care of at least four or five cars while working on them.

A repair shop without the garage is profitable and can be started for much less capital. If the repair man is just starting out and his capital is limited the best plan is of course to start in a small way.

The best time of the year for opening a public garage or repair shop, is in February or March. At that time owners are getting their cars out of dead storage, are buying new machines, or if they are dissatisfied with the place in which they are storing their cars, they are prepared to make a change. It doesn't make much difference as to the size of the city.

The question to decide is the one of whether you intend to do strictly repair work or store cars and repair, also conduct an agency for some car and carry supplies.

Garage.

A garage is termed a place for storing cars, but is sub-divided into departments; storing, salesroom, auto supply department, and repair shop.

The garage equipment consists of suitable space for the number of cars you intend to store, bearing in mind that the space devoted thereto should be utilized to the best advantage, for instance, cars which are used frequently and regularly should occupy that space where exit is easy, usually nearest the exit. The wash-rack should be in convenient location and garage supplies, such as oil, and gasoline should be where convenient, yet not interfere with the space occupied by the cars.

The salesroom, office, and stock room should all be carefully planned. The stock room quite often is utilized for small tools and accessories, but it is better to display the accessories in some sort of showcase or shelves in a space in the salesroom.

Repair Shop.

The repair shop can be subdivided into departments as follows: machine shop, tire repair, welding room, electrical apparatus and testing department. The testing department should be a space allotted for the purpose of diagnosing the troubles, before actual work is begun.

The electrical repairs constitute re-charging batteries, work on the electrical apparatus, etc.

By maintaining a system of departments in this manner, the parts belonging thereto are easily located, work turned out quicker and a higher degree of efficiency maintained.

An extensive line of repair work can be carried on in even a small garage, and the sale of extras and sundries will add materially to the income.

Garage and Shop Buildings.

Successful garage operation is largely a question of systematic economy. This holds true for smaller garages even more than large ones, and therefore such an establishment requires great care in its layout, construction and subsequent operation. The more thought concentrated upon the system to be followed, once the building and equipment are ready for starting business, the fewer mistakes will be made and the greater will be the profit derived from the undertaking.

A Nine Car Garage and Shop.

The type of a small country garage as described in chart 243 is designed for the storage and general care of nine automobiles. Besides the space necessary for garage work the building contains a well-equipped repair shop and an office which also serves as a reception room.

In the repair shop a limited supply of parts and supplies is kept, the latter being provided for the accommodation of the garage patrons. The supply stock consists of the most important accessories, tires, tubes and ignition sundries, etc.

A Fifteen Car Garage.

Including salesroom, accessory store and shop, is shown in chart 243-A, fig. 1 and 2.

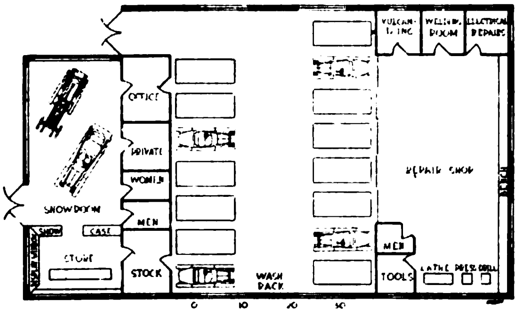


Fig. 1.—Plan view. The cars in front, near the shop doors should be the ones which are away from the garage the most.

Fig. 2.—Front view. Note the drive way to garage, gives the show room a corner appearance and light.

A 60x100 Garage Building.

Figs. 1 and 2: A one story building for a garage, salesroom, accessory store and shop—The scale drawing is shown in illustration to the left. The size of the lot is 60x100 feet. The building is erected so that another story can be added.

The entrance to the garage is exposed so that light can be obtained from two sides into showroom. Thus, you have practically all the advantages of being on a corner.

There is a small accessory store divided off from the showroom by showcases and an arch, a stockroom, private and general offices, rooms for men and women, garage space for fifteen cars, washrack, a shop big enough for five or more cars, and equipped with vulcanizing, welding and electrical rooms.

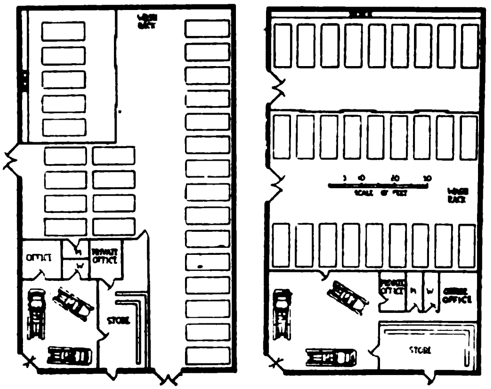


Fig. 3.—Left—complete establishment located on corner and with front entrance. Fig. 4.—Right—same with no front entrance.

A 66x112 Garage Building.

Figs. 3 and 4: A one story corner building for garage, salesroom, accessory store, offices, toilets, garage and shop. Size of the plot is 66x112.

There are two designs: fig. 4 is probably the preferable one considering all the conditions, but fig. 3 is the one to use in case a front entrance to the garage is considered essential.

The objection to the front entrance is that it restricts the frontage so that the display space for showroom and accessory store is rather small, but with the entrance on the side full advantage of the front may be taken and inasmuch as it may be considered as valuable advertising space it is essential to use all of it for display purposes. The question to decide is whether the advantage of having the whole front for display more than offset the disadvantage of having the entrance to the garage on the side street. Even if the garage trade is the most important part of your business, and evidently it is not, the side entrance is not very objectionable provided there is a large sign at the front stating that the garage entrance is on the side street.

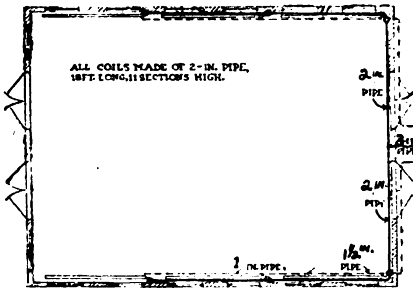
Fig. 3 has capacity for only five cars in the repair shop. Entrance to the garage is from both streets, but when the demand for space is strong, the last cars in at night may be placed in the side entrance way.

Fig. 4, which has no front entrance for cars, is not only a more attractive building to look at but also the layout of garage and repair shop is more convenient.

As far as storage capacity is concerned there is little to choose, fig. 3 having room for twenty-eight cars, including five in the shop, and fig. 4 having space for one less, including nine in the shop. The shop in fig. 3 may readily be enlarged if desired, by lengthening it.

Steam Heating a Garage.

As an example we will give the dimensions for garage 48x62: It is assumed that it is a steam heating system working at a pressure of 5 lb. gauge and you will use an ordinary low-pressure steam boiler, such as is used in heating houses. (See fig. 2 this illustration for a suggested plan.)



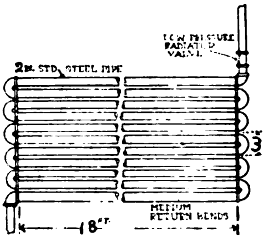
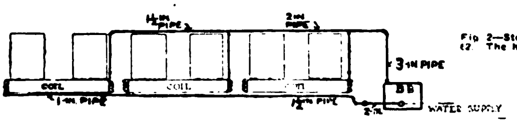


Fig. 2—Steam heating system for garage 48 x 62. The heating coils are made of steel pipe 2 in. in diameter



If you intend to place the boiler outside of the garage, you do not want to overlook the fact that it should be suitably housed, so that no heat will be wasted in warming the open atmosphere.

The boiler must be set so that the water line will be below the level of the lowest radiator or coil, so that the condensation will drain from the coils back to the boiler by gravity. If this is not done, the heating system will be very inefficient, as you will have to heat cold water up to the steaming point, instead of being able to reclaim some of the heated water.

CHART NO. 243A—Suggested Lay-out for Two, One-Story Garage Buildings. Steam Heating Coils.

m Motor World, by Harold F. Blanchard.)

A Twenty-Eight Car Garage.

Including salesroom, accessory store, office, toilets and shop is shown in chart 243-A, fig. 3 and 4.

Heating a Garage.

The usual plan is by steam, or hot water. The method of assembling the pipes or coils is illustrated in chart 243-A. For garages of larger capacity there would be more coils and a larger boiler.

Lighting A Garage.

Fig. 5, chart 243-B, illustrates types of lamps, reflectors, and the placing of same to advantage.

Pointers on Office Work.

While it is very important to operate the office in a systematic manner, about seven out of ten neglect this part of the business. In chart 243-B, a system of repair checking cards and how to use them is fully explained.

The office, (fig. 1, chart 243) which is also equipped as a reception room; contains, in addition, a desk, table, chairs, safe and couch. The office is lighted by two 40-watt Mazda lamps with 12-inch diffusers. The price of the office furniture and safe is about $100.

The system designed to take care of all the business of this garage is exceedingly simple. To carry it out, only three forms are required; a monthly **checking sheet,** a monthly **supply sales sheet** and a **repair card.** In addition to these forms an ordinary ledger is used, in which each customer is given a page on which all his charges and credits are entered. (See chart 243-B.)

*Garage and Repair Shop Prices for Storage and Repairs.

The prices below are not standard but are about as near standard as can be compiled. Note the difference in prices to those who purchase gas, oil and grease from the company and who are regular customers and transients.

Per Month—(Regular Customer).	
Roadsters, small, list under $1,400	$15.00
Roadsters, large, list over 1,400	20.00
Tour. cars, small, list under 1,400	17.50
Tour. cars, 5-pass., list over 1,400	20.00
Tour. cars, 7-pass., list over 1,400	25.00
Coupes and enclosed cars	25.00
Limousine	30.00
Electric—(Regular).	
Runabouts	$30.00
Coupes, victorias, etc	35.00
Cars with Edison equipment extra	5.00
Transient.	
Wash, polish and storage, first night	$2.00
Wash, polish and storage, each additional night	1.50
Storage only, per night	1.00
Dead Storage.	
One-third regular rate	Per month
Separate body storage, per month	$5.00

Repairs Per Hour.		
Day labor, according to work	per hour	$0.60
Night work and outside work	per hour	.90
Sunday and holiday labor	per hour	1.20
Shop room for chauffeurs when owners furnish tools	per day	1.00
Chauffeurs furnished to drive owner's car (day)	per hour	.60
Chauffeurs furnished to drive owner's cars (night)	per hour	.60

We will not be responsible for cars left for repairs or storage in case of fire, water, cyclone or other accidents, or if car is damaged in delivery to and from our garage.

We are not responsible for articles left in cars or in the shop.

Note—the above is printed on a heavy card, 14x24 inches, framed and placed in a conspicuous place.

**Fixtures for a Garage and Shop.

Fixtures for the repair shop should consist of such things as: Shelves and racks for tools, such as stocks, hack saws, etc., should be on the walls at the back of the vise. A set of stout drawers for keeping bolts and screws and brass rods should be provided. Some of the drawers should be fitted with locks and keys, for sometimes tools will disappear. Several shelves should be put up for storing various spare parts, mandrills, etc., but it must be remembered that the shelves when full may have to carry a very considerable weight; they should be stout and well secured.

Fixtures for the garage would also consist of such parts as lubricating oil tanks, gasoline tank, wash hose and washing rack, heating plant, turntable, stock room, etc.

A heating plant, either hot water or steam with coil pipes or radiators must be provided. This plant should be in a cellar or on the outside of the building in a small brick enclosure.

A turntable is very handy for garages and should be placed in the center of the garage.

Next, fit up a wash rack as explained in chart 246. For the lubricating oils, a small enclosure can be provided made of wire fencing with a lock and key. A stock room is next in importance, as explained on page 601.

The gasoline supply should be stored in an underground tank, placed some distance from the building, from which it is piped to a pump located inside of the building near the wash rack. The gasoline tank should have from 120 to 280 gallon capacity. (See chart 244.)

A **gasoline pump** can be connected to a tank under the sidewalk or in the rear.

A Western gasoline pump, with the stroke adjustable for 1-4, 1-2, 1 and 2 gallons, and equipped with a 280 gallon tank, is

---

*See page 574 for standard price charged for Tire Repairing.

**See Instruction 46D. for useful home made devices for the Shop.

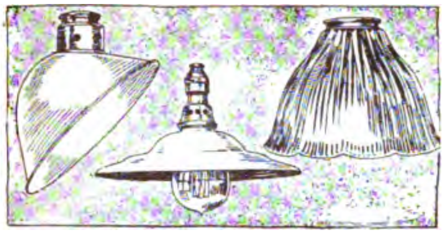


Fig. 5.—Three types of reflectors for lighting garage: Holophane type D'Olier steel type; 12inch diffuser; Intense type D'Olier.

Lighting the Garage.

Fig. 5.—Lighting the garage—(applies to fig. 1, chart 243), but can be applied to other garages of larger size by adding additional lights.

Naturally the repair shop requires even more elaborate lighting facilities than the garage space. It is therefore equipped with five 60-watt lamps and two 25-watt lamps, all of which are of the Mazda (tungsten type.) Three 60-watt bulbs W, fitted with Holophane D'Olier steel reflectors, fig. 5, and dropped from the ceiling to illuminate any part of the car being worked on, while two 25-watt lamps (W1) (shown in the shaded circles fig. 1, chart 243), are fitted with the same sort of reflector and are so located as to be useful in seeking parts stored on the stock shelves (S1).

Two 60-watt lamps (U) with Holophane intensive glass reflectors are dropped above the lathe, planer, and drill press, to shed a concentrated light on the work.

Artificial illumination of the garage proper is supplied by five 100-watt Mazda lamps, equipped with 12-inch steel diffusers with white enamel finish, fig. 5.

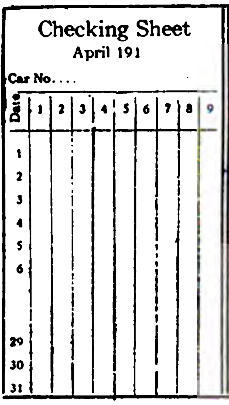
Special lighting provision is made for washing the cars; there are four 25-watt Mazda lamps located at the corners of the washrack, and these lamps are held in Holophane D'Olier steel reflectors, directing the light to the lower part of the automobile being washed.

See also page 465—how lights can be utilized for **battery charging** also.

Checking Sheet, Sales Sheet and Repair Sheet.

As referred to on page 599. The office work can be greatly lessened by using this system.

The checking sheet, fig. 2, is 3 feet high by 11 inches wide, with nine 1-inch-wide columns, allowing sufficient space for checking one car in and out every day of the month. Thirty-one horizontal lines are ruled one inch apart and the dates are printed under the heading "Date." Thus one square inch of space is provided for car "out" and "in." The checking times are entered by the day workman, who spends his time keeping garage and cars in shape. After the end of the month the sheet is filed for future reference.

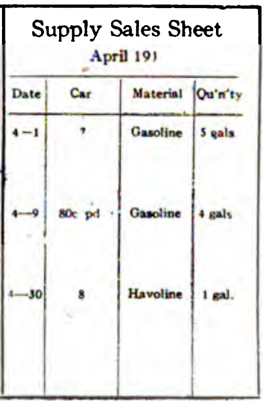


Checking Sheet

April 191

Car No....

Date	1	2	3	4	5	6	7	8	9
1									
2									
3									
4									
5									
6									
29									
30									
31									



Supply Sales Sheet

April 191

Date	Car	Material	Qu'n'ty
4—1	7	Gasoline	5 gals
4—9	80c pd	Gasoline	4 gals
4—30	8	Havoline	1 gal.

Fig. 2. **Fig. 3.**

Fig. 2.—Monthly checking sheet for cars housed in garage.

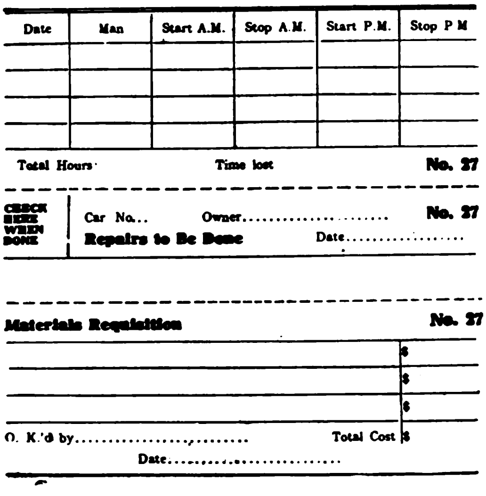
Fig. 3.—Monthly supply-sales sheet kept with checking sheet.

Gasoline, oil and other supplies bought by garage patrons are noted on the supply-sales sheet, fig. 3. If this sheet is made as large as the checking sheet it will last a full month. On the last day of the month the sheet is taken off its board, the sales are entered on the car owner's pages in the ledger and the stock records corrected in accordance with the sales record. Then the monthly bills are sent to the patrons. Where materials of any kind are sold to any but regular patrons, the price and the notation "paid" is entered on the sales sheet instead of the number of the car.

For the handling of repairs the repair card, fig. 4, is designed. These cards are used in series and are numbered consecutively. They consist of three portions with perforations between. The middle portion is filled out when a car is brought in to be repaired, the name of the owner, number of car and date of the order being written on the blank. Then follow the specifications of the work to be done. The card is then attached to the automobile and accompanies it to the repair shop.

The upper portion of the card is now used as a time card, the name of the workman and his starting and stopping times being entered upon it. As the work progresses the man checks every item of the work, and finally enters his total working time on the card. If it be necessary to draw upon the repair parts stock or buy material from outside, the lower portion of the repair card is used as a requisition, upon which the needed material is entered. If it is not in stock, and has to be bought, an order is made out after the requisition. In every case the cost of the repair part is entered on the requisition, which is O. K.'d by the owner before an order is sent out. The repair work being completed, a charge covering time and materials of the repair is made out from the parts of the repair card and entered on the ledger page of the car owner. Thus when the monthly bill is made out all charges against a patron come up at once.

When the repair card is no longer needed it is filed away under its number, the file being kept, with the ledger, in the safe of the office. This makes a very compact system, all parts of which are accessible to the owner of the garage at a minute's notice, thus enabling him to keep his operations on a high plane of efficiency.



Date	Man	Start A.M.	Stop A.M.	Start P.M.	Stop P.M.

Total Hours Time lost **No. 27**

CHECK HERE WHEN DONE | Car No... Owner.......................... **No. 27**

Repairs to Be Done Date......................

Materials Requisition **No. 27**

	$
	$
	$
O. K.'d by.......................... Total Cost	$

Date..............................

Fig. 4.—Practical repair card, combining repair order, material requisition and time card of work·

HART NO. 248B—Lighting the Garage—Office System Pointers.

sold by the maker for about $200. A curb gasoline outfit is shown in fig. 10 chart 244.

Lubricating oils should be carried in about three grades: Light, medium and heavy gas engine cylinder oil, also gear case oil and greases. (see chart 244.) Sixty gallon tanks are usually provided for lubricating oils, and all are placed near the gasoline pump.

A lubricating oil tank and a pump capable of delivering anything up to the consistency of transmission grease, are made by concerns mentioned at bottom page 602. The entire gasoline and oil outfit would cost about $250. Smaller and cheaper lubricating tanks can be had as per **charts** 244 and 244-A.

Many useful devices, in the way of time saving additions are shown in charts 245, 246 and 247, also see air compressors, charts 237-A and 237-B.

A forge is indispensable; if it burns coal, it should be under a separate roof. Gas is used quite extensively, however, for this purpose and may be placed in the shop. A good portable blacksmith outfit is shown in chart 247-G.

An inspection pit is useful, placed at any convenient place where the auto can be run over it. The pit permits the repairman to get under the car and work and should be installed. (See charts 244-A and 245.) The writer's pit is 6 feet long, 2 feet 9 inches wide and 2 feet 9 inches deep. A mirror is very handy for throwing the light in dark corners when at work in the pit under the car.

A chain hoist, for lifting the engine and other heavy parts, will pay for itself many times over in time and labor. (see chart 247-G.)

Fire extinguishers should be kept handy. The only part of the building, (if made of concrete or brick), that is liable to fire is the roof. In case of fire—keep two or three buckets of sand handy (or fire extinguishers) to put out gasoline fire, as water is useless.

A water connection in the repair shop will be handy and should be installed.

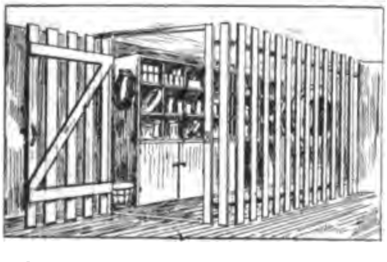
Electric lamps with wire guards and a long cord for working around the car is very necessary.

There is no end to the number of useful devices which can be installed in a repair shop and garage. We have selected those which are most necessary and will now suggest other desirable devices for use around a shop. (See charts 245 to 247 and Instructions 46 to 46-D.)

The Stock Room.

More money is lost in the repair shop and garage by having supplies scattered over the shop promiscuously, than in any other part of the business.

Every repair shop no matter how small should provide a stock room with a good lock and key and everything in the way of supplies kept therein.



See charts 247-A, 247-B, for list of supplies.

Systematic arrangement and a place for everything and everything in its place will save time and money.

The stock room is generally placed in some convenient place in the garage or repair shop. It is usually constructed of lattice work with good Yale lock on the door. In large shops the stock room is in charge of a responsible person, whose business it is to keep the stock replenished and deliver material to the workmen and customers.

Supplies in the rubber line. Repair shops can make extra money by carrying rubber supplies which are generally made by tire concerns, such as automobile spring bumpers, rubber horn bulbs, collapsible rubber buckets, etc.

Automobile rubber mats which comes in rolls 3-32 to ⅛ inch thick and 35 to 48 inches wide Matting also comes corrugated and perforated.

Radiator hose, tire tape. Rubber tubing for gas; tire inflating tubing; comes in black, white or red. Sizes ⅛, 5/32, 3/16 and ¼ inch inside diameter.

**Money Making Additions.

There are several extra additions which can be added, all necessary and well worth the investment.

Tire department; a small or large vulcanizer for repairing tires, see fig. 2, page 610.

A battery charging department; for recharging, starting, lighting and ignition batteries, see fig. 1, page 610, 460 and 462.

During the winter months, there is much more of such battery recharging work brought to the garages because the cold weather reduces the charge-holding capacity of the storage batteries, while at the same time the cold engines require more current from the batteries to start them.

Oxy-acetylene outfit for welding and carbon cleaning, pages 610 and 727. Of course, with all this more room will be necessary, but it is surprising how small a space all the above can be carried on in, if properly planned out.

There is quite a profit in handling lubricating oils, grease and gasoline, and, if possible, an equipment for handling same should be added.

The car rental service is something worth considering and can be added in time.

A supply department is very remunerative, providing the proper supplies are carried.

---

*See Instruction 46-D for useful Home-made Devices for the Shop.
**See page 848 for repairing tops.

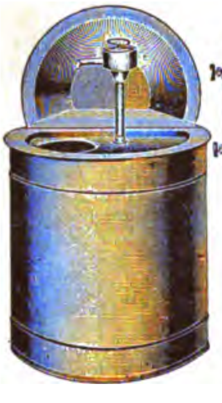


Fig. 1—Lubricating oil tank. This tank can be used for engine oil and general lubricating oil. It is made of galvanized steel and holds 60 gallons. Fitted with a positive action force pump. The advantage is that it keeps the oil covered and free from grit and dirt. The Bowser Co. of Ft. Wayne, Ind. make a more elaborate affair.

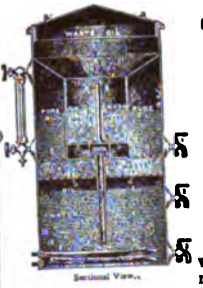
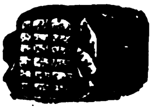

Sectional View.

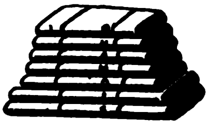
Fig. 2 — The cross oil filter will save oil which is wasted by filtering the used oil through this filter. It will also rid the oil of grit and mineral substances.

Fig. 3 — A waste can is required by the insurance companies, instead of throwing greasy, oily, inflammable waste on the floor, it is placed in this can. Every garage should have this waste can.

Fig. 4—The dover gasoline and radiator filler will prevent spilling and is very easy to handle. It holds 5 gallons. It is not advisable to put gasoline in the same vessel used for water, but if it is necessary, then place a chamois skin in the funnel, pour the gasoline through it. No water will then pass into the gasoline tank.

Fig. 5—Illustrates a smaller size of dover radiator and gasoline filler — advisable to have one each for gasoline and water. This filler is also suitable for lubricating oil.



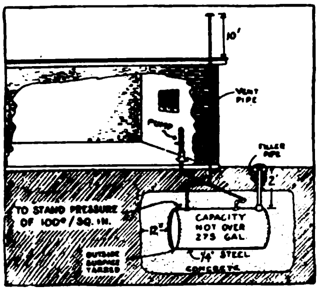


In selecting sponges, chamois and waste, it is advisable to use only the best.

Waste usually comes in bales of 50 or 100 pounds. It is economy to buy waste by the bale. Nothing but the very best white waste is suitable for automobile work. When waste has been used and ready to throw away, place it in a can, see Figure 3.

Chamois Skins are used for washing and cleaning the body and fine surfaces. It is a difficult matter to obtain a good genuine chamois skin, but it is worth the difference in price to get the best. The French chamois skin seems to be the most durable and pliable. Chamois skins come in sizes 28x32 inches and 19x21. A package of chamois generally contain a dozen.

Sponges often times contain sand and grit, especially the cheaper grade. Many cars have received scratches which cannot be removed by using the cheap gritty sponge. The best sponge is the Rock Island Sheepswool sponges. They come in bales of 15, 25 30 and 50 pounds.



The gasoline storage tank to supply gasoline inside of garage to a pump placed away from the tank, requires special installation on account of the insurance. The tank can be placed in the ground 18 inches below the surface. The Insurance Co.'s are very strict. The above plan is one that passes inspection in New York City.

Give tank 3 coats of asphaltum.

Address some of the storage tank manufacturers: Western Oil Pump & Tank Co., St. Louis Mo. O. K. Harry Steel Co., St. Louis, Mo. Wayne Oil Tank Co., Ft. Wayne, Ind. American Oil Pump Tank Co., Cincinnati, Ohio.

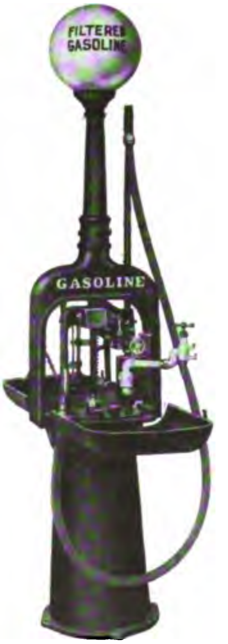


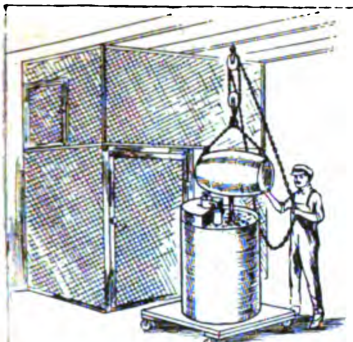
Fig. 10. Curb gasoline pump.

Fig. 10. A curb or road-side pump is shown. An electric light fixture with globe is placed above. The storage tank is buried under ground, usually as close to pump as possible—it is connected by a 1½ inch suction pipe with foot valve placed at the end of suction pipe. Standard tanks range from 1 to 20 bbl. capacity. Parts are: foot valve, vented fill pipe with lock, suction pipe and gauge stick. (The Am. Oil Pump & Tank Co. Cincinnati O.)

An air pressure gasoline system is Mfgd. by Allen Pressure System Co., 1926 Broadway, N. Y.

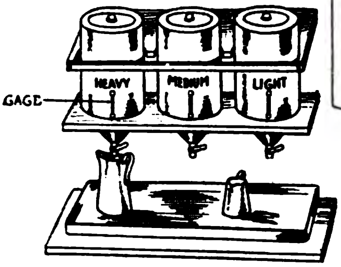
Fire extinguishers should be in conspicious places about the garage. Gasoline often drips from a carburetor and back firing or a spark from a muffler will ignite the gasoline. Once a gasoline fire is started it is difficult to extinguish. Never use water; it will only serve to float the gasoline and spread the flame. If a fire extinguisher is not on hand, keep a box of fine earth or sand and dash over the flame. Flour will also do if nothing else is handy.

CHART NO. 244—Oil and Gasoline Equipment. Waste, Sponges and Chamois. Gasoline Storage Systems.



OIL TRANSFERRING SYSTEM

Oil may be most readily transferred from the barrel to the storage can by the aid of a differential pulley and suitable grab-hooks. The differential pulley may be fastened to the ceiling beams just over the oil storage room doorway, and if the storage cans are mounted on castors in the manner shown, they may be easily rolled under the suspended barrel, a hole drilled in the bung, and the oil transferred without further attention. The oil storage room shown in the sketch has several valuable features. First, the oil may be locked up, and is only accessible to the proper persons; secondly, the upper part contains a shelf in which the surplus stock of heavy oils and greases are stored.–



OIL-STORAGE TANKS

The common type of oil-storage tanks requires a pump and does not provide a convenient place for keeping the measures. Gravity flow is somewhat handier and the installation requires less floor space. A simple method of storing several grades of oil and having them on tap is illustrated. The tanks may be made by any tinsmith, and are provided with gage glasses that show at a glance the amount of oil on hand. The conical-shaped bottoms permit the draining of the last drop of oil and prevent the collection of any sediment. A shelf provided with a drip-pan offers a convenient place fo·· keeping the receptacles.

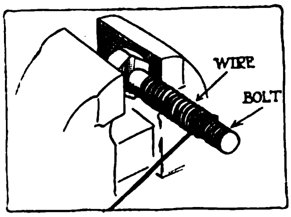
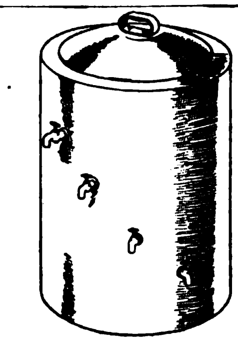


Fig. 4—How spring is made by winding wire around bolt



OIL-SETTLING TANK

The oil drained from the crankcase is usually a dead loss, as it is unfit for further motor use. It is, however, suitable for lubrication of farm machinery or such light implements as the lawn-mower and the wheelbarrow, and may be reclaimed by the settling tank shown. The old oil is poured into the tank as fast as it collects and the sediment allowed to drop to the bottom, the clean oil rising to the top and being drawn off as required. The resale price should be made low to attract the trade, and is almost a clear profit.—

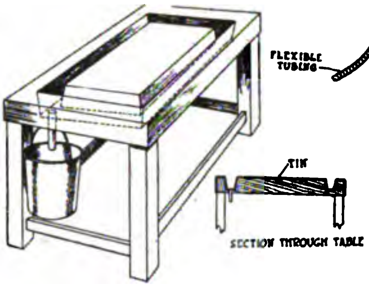
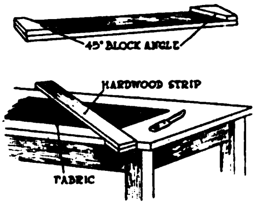


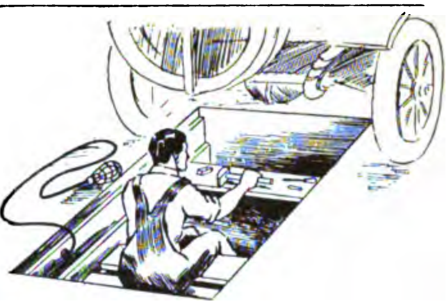
TABLE FOR WASHING PARTS

For any given quantity of gasoline a maximum of service with a minimum of waste in washing parts may be obtained by the use of the washing table shown. The table is covered with sheet metal, the feature being the trough around the edge which serves as a return to the pail for the washing liquid. In returning, much of the heavier grease is dropped and may be scraped up and deposited in a can kept for that purpose.



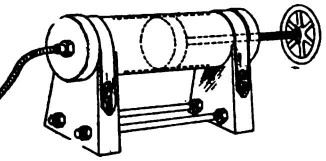
CUTTING TIRE FABRIC

A simple but effective device for permitting fabric to be cut on the bias, with a wet knife, instead of shears, is illustrated. A hardwood strip, forming the straight edge, is placed 45 deg. across the tire repair bench, and each end fitted with hardwood angle blocks in the manner shown. These edges even up against the edge of the bench and secure a perfect 45 deg. cutting angle.–



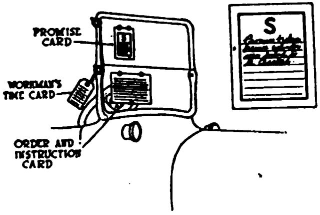
REPAIRSHOP PIT

A concrete repair pit, the depth of which may be varied, is illustrated. Ledges are provided at different heights and boards may be placed across, giving the mechanic free access to the work. Much of the dampness of this type of pit is removed by the wooden floor and the space beneath. Several of the boards on one of the upper ledges may be left in place and used as shelves for the tools and for steps in getting into and out of the pit.—



A POWERFUL GREASE GUN

A powerful grease gun for filling universal joints and steering gears is illustrated. The barrel of the gun is a piece of 6-in. pipe about 16 in. long, and carries a metal piston having a single ring. This piston is forced downward through the action of a threaded rod, screwed into a cap at one end, and operated by a hand wheel. The other end of the barrel is likewise covered with a cap and carries a length of flexible tubing, through which the grease is forced to the part. The barrel is mounted on wooden uprights, and is large enough to permit one loading to supply several joints. The amount of grease used each time may be readily determined by weighing the gun before and after using



PROMISE-RECORDING SYSTEM

A visible promise-recording system is shown. When the car reaches the repair-shop floor, the work to be done is noted from the instruction card, and the job promised to be done at a certain time This promise is recorded by means of a heavy bordered card, pasted to the windshield and having the initial letter of the day of the promise printed at the top center. For example, if the car is promised for Saturday, a card having the letter "S" is used; if Monday, the letter "M." The foreman can then instantly see what must be got out each day and what promises are broken, and why.

CHART NO. 244-A—Miscellaneous Additions for Garage and Shop. Many other useful shop d vices are shown in Instruction 46-D.
(Motor World.)

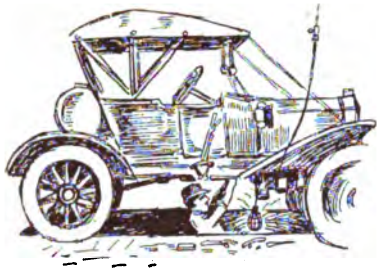


Fig. 1—A pit is provided in most shops. The car is rolled over the pit. Size of pit is usually 6 ft. long, 2 ft. 9 in. wide and 2 ft. 9in. deep.

A very well laid out plan for a pit is shown in chart 244-A.

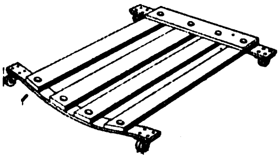


Fig. 3. Durable creeper.

***This creeper is easily made, and strong enough to permit a car to run over it without injury. Cross strips are 2x½ inch steel and bent slightly to give clearance for the swivel castors and yet keep** body of creeper low. Slats are 4x¾ in. hard wood.

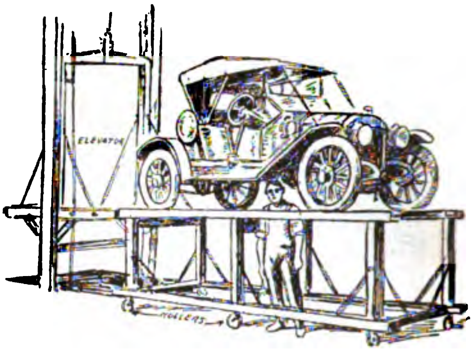


Fig. 2—Portable structure for working under cars where there is an elevator.

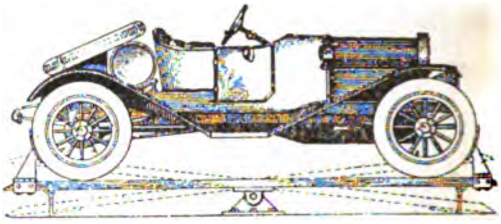


Fig. 4—A see-saw arrangement for working under car.

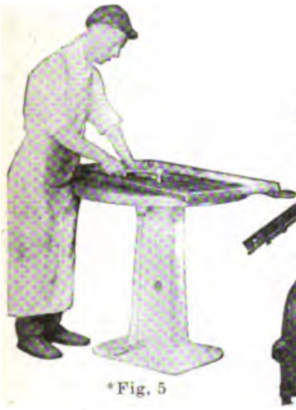


*Fig. 5

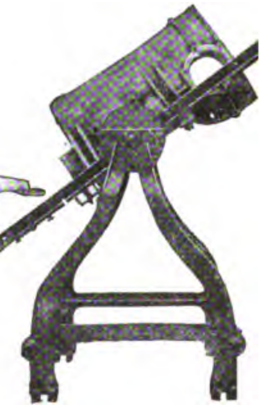


***Fig. 5A—The Continental** adjustable engine stand.

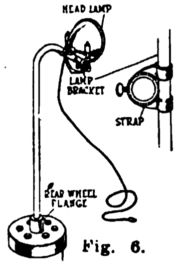


Fig. 6.

This portable service lamp was made both for night service in the shop, and for work on the road. A standard headlight, together with its bracket, is clamped to a pipe upright, bent as illustrated. This upright is fastened to a base that is an old rear wheel flange bolted to a brake drum. Current is derived either from direct connection with the storage battery or by plugging into the dash lamp circuit.—(Motor World.)

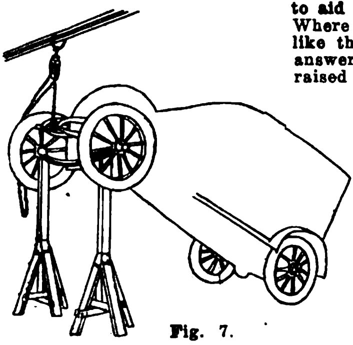


Fig. 7.

Fig. 1—An inspection pit is useful; placed at any convenient place where the auto can be run over it. The pit permits the repairman to get under the car and work.

The pits are usually made as per the dimensions under the illustrations. A mirror is very handy for throwing light in dark corners when working under a car.

Fig. 2—Where there is an elevator and no pit. The structure serves the same purpose as a pit with the additional advantages of being portable, more cleanly, and more accessible. It permits the workmen to perform most of their operations by daylight instead of subjecting them to the inefficient glare of an electric light bulb. No skids are required with this structure in any garage where an elevator is provided; the elevator with the vehicle upon it is simply brought to a stop at the height of the truck and the truck then adjusted so the car can be rolled upon it. Being mounted on casters, the truck can be moved easily to the lightest portion of the shop.

Fig. 4—A good many devices have been invented to aid in getting under a car for doing repair work. Where it is impossible to make a pit, something like the illustration will be found useful, and will answer the purpose. As will be seen it can be raised to rest in a horizontal position, or either the front or rear may be raised as required.

When at an angle, the front or rear may be raised two feet. When in a horizontal position, as shown in the illustration, the elevation is about one foot. The apparatus consists of a light swinging runway upon which the car is pushed. When the repair work is at the forward end of the car the front is raised, and thus there is plenty of room to work. When the work to be done is at the rear of the car, the opposite incline is given. The method of fastening the car on the incline shows for itself. It consists of two hinged pieces which rests against the wheels.

Fig. 7—Another method for working under a car: Front end of car is hoisted by chain and special made wood jacks are placed under axle. The stands or jacks must be designed for least space possible—in order to give working room between them.

***Fig. 5—The Continental assembly** and welding table greatly helps to speed up all kinds and types of assembly work. It is not necessary to continually change the position of the article which is being worked on, in respect to the table, as the table may be revolved and the work comes to the right position. The table is instantly locked.

CHART NO. 245—Different Methods for Working under Cars.

---

*See advertisement of Continental Auto Parts Co. in back of this book.

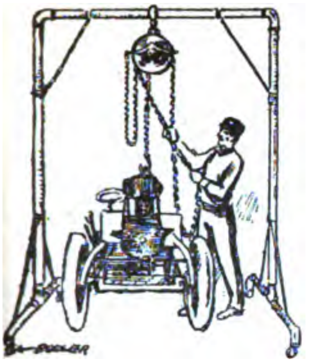
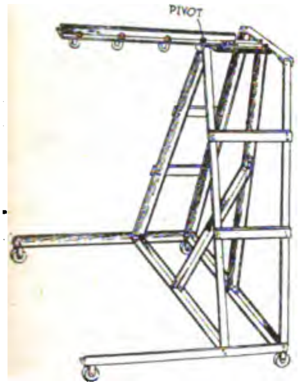


Fig. 4—A chain hoist and frame s shown above is a necessity in repair shop for lifting engines rom chassis. The frame is made f heavy iron pipe with rollers, lso see other charts under "Reair Shop Hints," Inst. 46-D.



The feature of this crane, which s made of structural steel and aounted on four castors, is that he overhanging arm is pivoted so hat it may be swung from side to ide. The block and tackle may e attached at three points on this rm. The swivel feature of the rm is a convenience in removing r replacing an engine, as it alows for fine adjustment or failitates removal by enabling the ngine to be swung out over the hassis with a minimum of effort. he construction is very substanial.

This is an ideal shop crane or oist which can be moved from lace to place. By running the ower part under front of car, the ngine or parts can be lifted. fanufactured by The United Engine and Manufacturing Co., Ianover, Pa., another type called he "Canton" is supplied by the t. Louis Machinist Supply Co., t. Louis, Missouri.

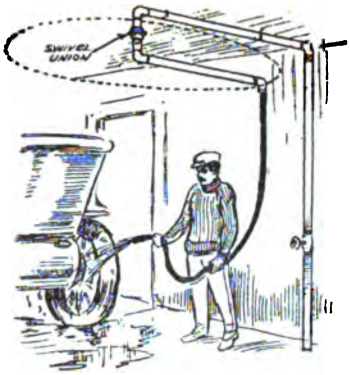
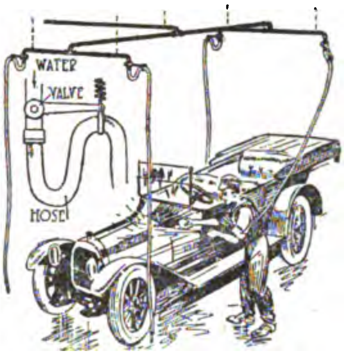
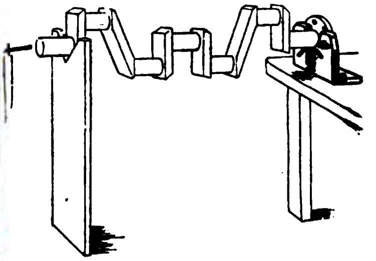


Fig. 5—Portable hose swing rack for washing cars. This rack is made of standard pipe and fittings. The illustration gives an idea of its construction.

A wash is usually made about 12 or 14 ft. wide and about 15 or 18 feet long. It is made of granitoid arranged so that the water flows to a trap in the center for draining.



A washer with several hose outlets, which meets all requirements and is not likely to get out of order is made out of four lengths of hose suspended from pipe connections at the four corners of the wash rack. Each hose is connected to a plug valve which is spring-closed and opened by a slight pull on the hose. The advantage of the four-hose construction is that it is simple, not apt to get out of order, and allows more than one man to work on a car.



When the crankshaft has been removed and the connecting-rod bearings are to be scraped, the bracket shown will be found convenient for holding the crankshaft on the bench. It is merely a metal angle with slots for bolts which go through the crankshaft flange. The support at the other end is a notched board.

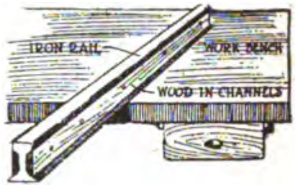
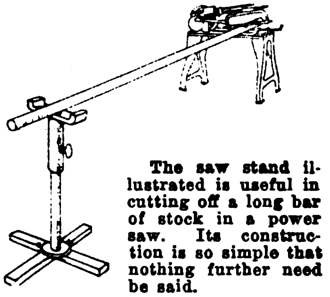
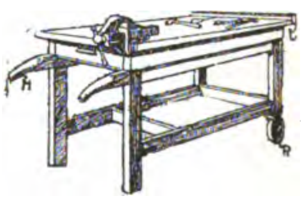


Fig. 6.

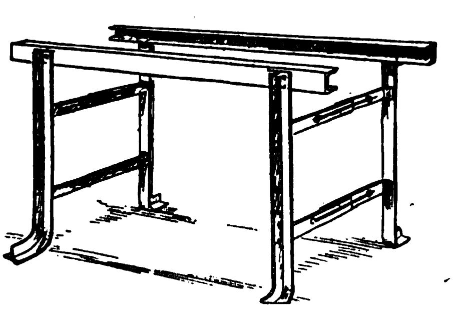
*An iron rail is a useful device for any shop.



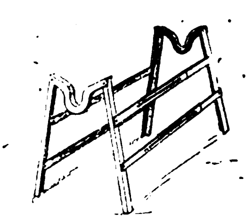
The saw stand illustrated is useful in cutting off a long bar of stock in a power saw. Its construction is so simple that nothing further need be said.



*A portable work bench—an improvement would be to add shelves underneath for parts. Note the rollers (R) and handles (H).



*An engine stand that is adjustable as to width, and that is very light yet strong, can be made out of structural steel. The top members are 4-inch channels, the legs 2x8 inch T iron, and the cross members are made of flat stock ¼x1 inch.



Another home made stand, for working on axles.

IART NO. 246—Time and Labor Saving Home Made Devices for the Shop and Garage—also se charts 302 to 308-A.

*See advertisement of Continental Auto Parts Co. in back of book.

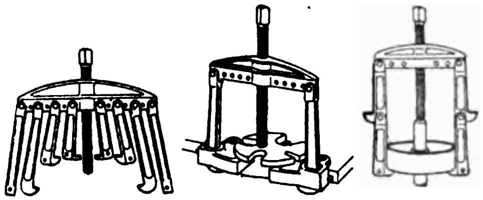


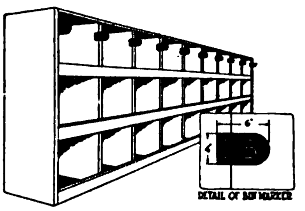
Fig. 1 Fig. 2 Fig. 3

Crane wheel pullers—a complete outfit is shown.

Fig. 1—the complete outfit with various length attachments; **Fig. 2**—a special attachment which makes an arbor press; **Fig. 3**—removing a fly wheel. Mfg'd by—Crane Puller Co., Arlington Mass., also write to W. E. Prudden Hdw. Co., 864, 8th ave. N. Y., for information on another type of wheel puller.

Pulling a wheel from a rusted axle is a bigger job than it appears. If the axle is greased before the wheel is put on, the probabilities are it will come off readily, if not it will, more than likely, be a task. A wheel puller can be bought of any auto supply house or one can be made by local blacksmith. Every repair shop needs a wheel puller.

A wheel puller can also be utilized for removing fly wheels, transmissions, gears, collars, pulleys couplings, marine propellers, etc.



This stock bin marker permits ready location of any bin in the stock room. It is a sheet metal tag, bearing the number of the bin to which it is attached. As it projects out into the aisle, and is large enough to be easily read, the location of any desired bin may be seen at a glance.

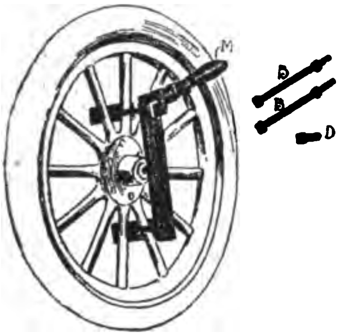
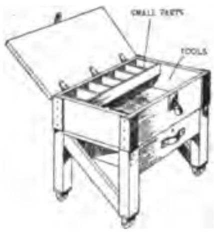
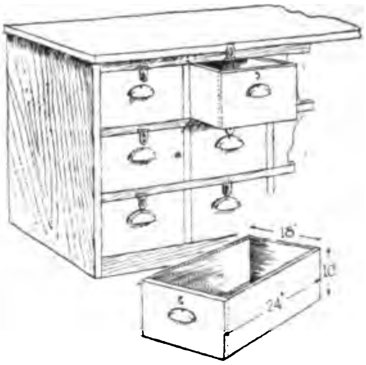


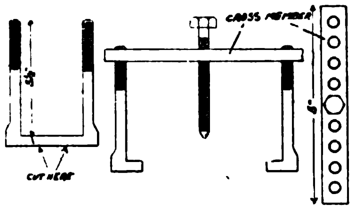
Fig. 4—This makeshift wheel puller is made from two long bolts B, with nuts, a short thick bolt D and three pieces of iron drilled as shown. These parts are applied to the wheel with the short pieces of iron behind the spokes of the wheel, and the bolt D communicating between the bar and the end of the axle shaft. By taking up evenly on the two nuts with the wrench M and occasionally striking the bar opposite the bolt D with a hammer, a very stubborn wheel can be easily removed.



This tool box is made integral with its base, and is mounted on castors, so that it may be taken to the side of the car upon which the work is to be done. The tool box proper is shallow, and contains a space for the more common tools, in addition to several small compartments for miscellaneous parts. The more valuable, precise and less frequently used tools are kept in a drawer beneath the box, which is locked unless in use.



Substantial drawers of large size provide convenient means for storing parts removed from cars that are being repaired. The usual method is to place the parts on the bench, but this is objectionable because there is always danger of them being mislaid or used on other cars. A drawer 10x18x24 in. is large enough to take all the ordinary parts, such as bolts, nuts, washers, carburetor, magneto, pistons, connecting-rods, bearings, etc. The drawer may be placed at the side of the car and as soon as all the parts have been removed it may be put back in the cabinet. A padlock safe-guards the parts until they are needed again. These drawers also aid in keeping the shop neat and protect the parts from dirt. The top of the cabinet may be used as a bench or table.

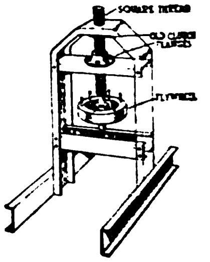


Wheel Puller Made from Spring Clip.

Fig. 5.—A home-made gear wheel puller: First get a piece of soft iron or steel. This piece must be 5 in. long and 1 in. square. Then find a long spring clip, the longer the better; cut the clip in two pieces at the bottom about ½ in. from the inside of the clip, then you have the arms completed.

To make the cross-member have a piece of iron or steel 1 in. square by 5 in. in length; drill a hole in the center and tap threads for a ½ in. bolt. Next you can drill three or more smaller holes on each side of the large center hole and tap these holes out to fit the threads on the spring clip; then you have an adjustment for three or more gears.

This home-made arbor press is made of channel sections from an old frame. It comprises an inverted U-shaped member, supported in an upright position on the channel base as shown. The overall height is about 5½ ft. and the width 4 ft. The pressure screw is carried on two large nuts that are old clutch flanges tapped out, both the screw and the nuts having square threads. An old flywheel, keyed to the lower end of the pressure screw serves as a hand wheel, and is provided with vertical pins so that a pinch bar may be used to increase the leverage.



(Arbor presses are manufactured by Weaver Manufacturing Co., Springfield Illinois.)

CHART NO. 247—Useful Devices for the Shop—continued.

(Motor World.)

Assorted copper gaskets (asbestos lined) for such places as valve caps, inlet and exhaust manifolds, spark plugs, carburetor flanges, etc.—see index "Gaskets."

Assorted nuts shown to the right—see page 609.

Supplies for the Stock Room.

Abrasive—for grinding in valves.
Asbestos—sheet and wicking.
Babbitt metal—for bearings.
Burrs—iron and copper.
Brake lining—see "Repairing brakes."
Bolts—stove and carriage, assorted sizes.
Body polish—brass and nickle.
Brads—assorted sizes.
Brushes—paint, scratch, file.
Bronze—cored bars for bushings.
Cap screws—hexagon head; standard and S. A. E.
Chalk line—for aligning wheels.
Cotter-pins—assorted sizes.
Carbide—in cans.
Cocks—compression and pet.
Castelled nuts—assorted sizes.
Chamois—for washing car.
Cotton wicking—for valve stem packing.
Cylinder oil—light, medium, heavy.
Card board—for liners.
Cup and transmission grease.
Candle wicking—for packing.
Clamps—hose and screw.
Carbon—rod and bar, for brushes.
Celluloid sheets—for top curtains.
Cloth—crocus and emery.
Drill rods and drills—
Dry cells—testing not less than 25 amperes.
Ells—brass; for gasoline and oil lines.
Emery flour—fine, medium and coarse.
Emery cloth—No. 00 to No. 1.
Electric bulbs—2, 4, 6, 12, 15, 18, 21 and 24 C. P. (nitrogen and tungsten.)
Felt—sheet and washers.
Fibre—sheet and block.
Flux—for soldering aluminum and brass.
Ground glass—for valve grinding.
Graphite—powdered and flake.
Grease cups—⅛, ⅜.
Gaskets—copper; assorted sizes.
Gas tips—½ and 1 ft. sizes.
Gas tank keys—for Prestolite gas tanks.
Hand washing compound—
Hexagon nuts—3-16 to ⅝.
Hardware—and raw material.
Hemp wicking—for packing.
Hose—for radiator and gas.
Hose clamps—for radiator hose.
Inner valve parts—for tire valves.
Iron—bars and rods.
Iron—sheet.
Inner shoes—for blow outs.
Key stock—in bars.
Kerosene—for general cleaning.
Keys—Woodruff and straight.
Leather—(heavy) for under radiator and bodies and refacing cone clutches.
Lard oil—for thread cuttings, tapping and drilling.
Lamp black—
Lock washers—¼ to ⅝ in.
Moboline—for packing.
Neats foot oil—for clutch.
Nails—assorted.
Outer shoes—for cuts in casing.
Pipe plugs—iron and brass ⅛ to ¾ inch.
Plugs—see spark plugs.
Paper—heavy brown, sand, emery.
Platinum points—for interrupters and vibrators.
Rivets—iron and copper, assorted.
Rubber—sheet packing 1/32 to 3/16.
Rubber—tubing for gas, air, tire, hose, (see tire.)
Rubber—matting.
Sheet—iron, brass, copper, tin and lead.
Shims—laminated.
Solder—half and half, string and aluminum.
Soldering compound—
Screws—machine, cap, lag, wood and set.
Steel rods—bar, tool.
Spark plugs—½ inch, S. A. E., metric (page 288).
Switches—push, snap.
Shellac—for gaskets, etc.
Spring—steel and assorted springs.

Steel bars: Few feet of ¼ inch, ⅜ inch, ½ inch, ⅝ inch, ¾ inch, ⅞ inch and 1 inch iron bars, also steel, brass and wire rods.

Tees—⅛, ¼, brass for gas lines.
Tacks—assorted sizes.
Tubing—copper, brass, for gas and oil lines ⅛, ¼ inch, this tubing generally comes hard, but can be annealed (softened) by heating it.

Tape—adhesive; for electric wiring.
Taper pins—¼ to ⅜ inch.
Unions—brass, ⅛ inch, and soldering connections for gasoline lines—chart 274-B.

Valves—for gasoline and oil lines, tire valves and oversize valves for engine.
Valve caps—for leading engines, valve caps for tire valves.
Wire—copper, brass, spring, piano, and insulated.
Wire—for wiring cars as; primary flexible cable and secondary cable.
Washers—punched, split, and brass.

*Copper Gaskets used for Spark Plugs.

S. A. E.—⅞ in. (inside dia. ⅞ in.) (outside dia 1⅛ in.)

Standard—½ in. (inside dia. 27/32 in.) (outside dia. 1 3/32 inches.)

Metric—(inside diameter 23/32) (outside dia. 60/64.)

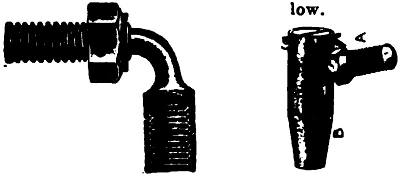
See page 238 for the different types of spark plugs, and chart 247-DD for sizes and dimensions and the proper wrench to use for the different types.

CHART 247-A—Some of the Supplies for the Stock Room. The selection and quantity is governed by the demand. See also pages 601, 608 and 609.

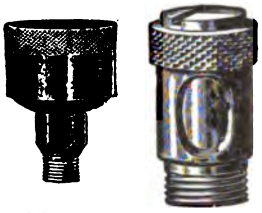
*See also pages 289 and 717.

Valve adjusters for placing over the valve end of Ford engine valves to take up wear and lessen noise.

Hose clamps are necessary. This type is the Sherman wrought brass clamp to fit radiator hose below.



Spark and throttle ball-joints used for connecting magneto timer levers and carburetor throttle lever, with levers on steering wheel. They eliminate all lost motion and give more perfect control. Screw end fits the timer and carburetor lever, tapped hole fits connecting rod.—They come 25 in a box, assorted (Stevens & Co..)



Grease and oil cups ought to be carried in stock room.

Sizes of grease cups run as follows:
000—⅛ in. pipe thread.
00—⅛ in. pipe thread.
0—⅛—or ¼ in. pipe thread.

Diameter of 000 is ¾ in., 00 is 1 in., and 0 is 1¼ in.

Oil cups run as follows:
No. 1—¼x32 thread, ⅜ in diameter.
No. 2—5/16x32 thread, 7/16 in. diameter.
No. 3—⅜x24 thread, ½ in. diameter.
No. 4—7/16x24 thread, 9/16 in. diameter.
E. Edelmann Co., Chicago, manufacture this class of material.

Radiator Hose.
(3 and 4 ply steam hose.)

4 ply hose		Price
¾	in. inside diam., per foot......	$ .50
1	in. inside diam., per foot......	.50
1⅛	in. inside diam., per foot......	.55
1¼	in. inside diam., per foot......	.62
1½	in. inside diam., per foot......	.75
1¾	in. inside diam., per foot......	.87
2	in. inside diam., per foot......	1.00
2¼	in. inside diam., per foot......	1.12
2½	in. inside diam., per foot......	1.25
2¾	in. inside diam., per foot......	1.35
3	in. inside diam., per foot......	1.50

Rubber hose for radiator should be carried in all stock rooms.

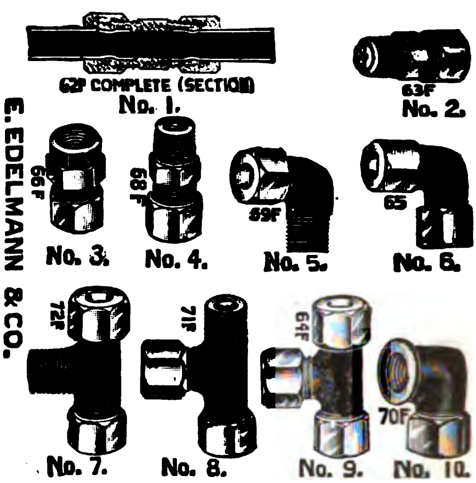
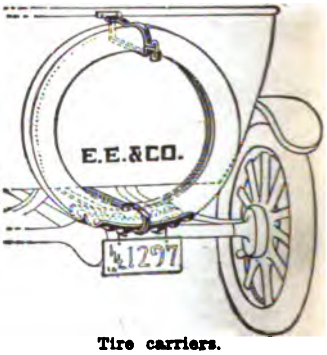


Fig. 1—Solderless fittings for gasoline, gas lines, etc. (1) Showing how ends are drawn together. (2) Check valve straight. (3) Tapered female ⅛ inch pipe one end. (4) Nipple union, male ⅛ inch pipe one end. (5) Elbow male. (6) Elbow coupling. (7) Tee coupling on opposite ends, ⅛ inch pipe thread (male) on other. (8) Tee angle coupling, male thread one end. (9) Tee angle on three ends. (10) Elbow coupling on one end, female pipe thread on other.

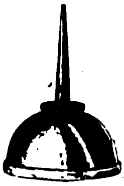
Exhaust cut-outs.

Exhaust "cut-outs" are frequently demanded by auto owners. Every stock room ought to have a few sizes in stock.

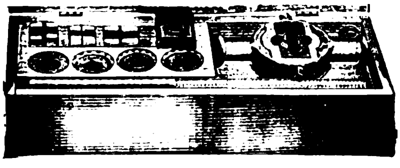
Many cars now days are equipped with tire carriers. Here is one easily applied and with lock, for the Ford. Made by E. Edleman Co., Chicago, Ill.



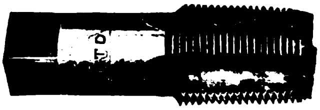
Tire carriers.



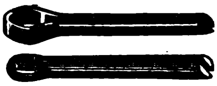
Oil cans.



Dies for threading small pipe, ⅛, ¼, ⅜, ½, inch, outfit No. C-260 made by Greenfield Tap & Die Corporation, Greenfield Mass., retail for $7.50.



Pipe tap for threading pipe fittings etc., (see chart 285-C).



An assortment of cotter pins, ¾, 1, 1¼, 1½ and 2 in. lengths.

CHART NO. 247-B—Miscellaneous Fittings and Supplies for Garage and Shop.

Oversize pistons.

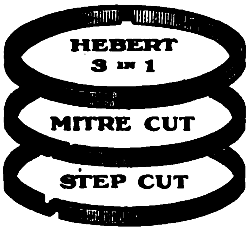
Pistons and Rings.

***Over-size pistons** are necessary when cylinders are rebored or reamed out. They can be had from firms mentioned below or from the manufacturers of the engine. Standard—over sizes for the Ford engine are .0025, .005, .010, .03125, .0625. Pistons are fitted with bushings, made of bronze and reamed.

Piston rings—assorted sizes should be carried in stock. To determine sizes to carry see "Specifications of Leading Cars"—pages 543 to 546, and note bore of different engines. Those sizes on cars you repair most, are the sizes to carry in stock.

****Over size piston rings** are at times all that are necessary, if cylinders are not bored out too much.

Mitre cut and step cut standard sizes are 3¾x4¼ inches and oversizes .0025-.005-.010-.015-.03125-.0625.



Standard and over size piston rings.

Partial List of Cars for Which Piston Rings in Assortment May be Used.

The following assortment is supplied by Stevens & Co.,— consisting of 125 high quality rings made up of 14 sizes; 3¾x3/16 to 4¾x5/16 inclusive—the sizes which are for many older model cars—see pages 543 to 546 for bore of later models.

3¾ x 3/16—Buick, Empire, Hudson, Moon, National, Overland, Pullman, Regal, S-G-V. Velie, White, Mitchell-Lewis.

3¾ x ¼—Ford, Jeffery, Marion, Metz, Paige-Detroit, Pullman, Velie.

3⅞ x ¼—Cameron, Chalmers, Lozier, Stevens-Duryea.

4 x 3/16—Alden-Sampson, Flanders, Interstate, Marion, Overland, Peerless, Regal, Velie '09.

4 x ¼—Abbott-Detroit, Auto Car, Chalmers, E. M. F., Franklin, General Trucks, Hudson, Jackson, Marion, Maxwell, Mitchell-Lewis, Moline, Moon, Oldsmobile, Overland '09, Packard, Paige-Detroit, Peerless, Pierce-Arrow, Stanley, Studebaker, Stutz, Velie.

4 x 5/16—Buick, Cadillac, Cartercar, Cole, Jackson, Maxwell, Oakland, Regal, Reo.

4⅛ x ¼—Allen, Abbott-Detroit, Hudson, Marion, Pathfinder, Pope-Hartford, Studebaker.

4⅛ x 5/16—Cartercar, Cole, Jackson, Oakland, Oldsmobile, Peerless.

4¼ x ¼—Brockway, Buick, Case, Chalmers, Federal, Franklin, Haynes, Interstate, Locomobile, Maxwell, Mitchell, Moon, Pierce-Arrow '08, Stutz.

4¼ x 5/16—Cadillac '10. Cartercar, Cole, Haynes, Marathon, Maxwell, Mitchell, Oakland, Oldsmobile.

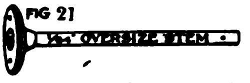
4½ x ¼—Abbott-Detroit, Apperson, Cartercar, Case, Franklin '11, Haynes, Interstate, Locomobile, Mercer, Moon, Packard, Pierce-Arrow, Rambler, Stearns, Velie, Winton.

4½ x 5/16—Buick, Cadillac, Cartercar, Cole, Maxwell, Mitchell, Oakland, Peerless. Pullman, Winton '09.

4¾ x ¼—Interstate, Jackson, Moon, Stevens-Duryea, Stutz.

4¾ x 5/16—Auto Car, Mitchell '09, Oldsmobile, Pope-Hartford.

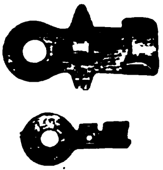
FIG 21



Standard and over size valves—rough and finished.

Over-Size Valve-Stems.

To be used when guides are reamed out. Usually only 1/64 inch, and it is therefore impracticable to put in a bushing. Weak suction and lean mixture troubles are generally due to leaking piston rings, but are also, in many instances due to worn valve stems and guides.



Copper wire terminals about ½ actual size.

Copper Wire Terminals.

Are a very handy article to have on hand, as a quick and permanent attachment can be made by their use. All wire ends should be fitted with terminals as this is the one big source of no end of trouble (frayed ends and poor contacts) with their use, this is entirely eliminated.

No. 2 is the right size for most of the primary cable used and No. 6 is for secondary cable use.

Thumb Screws and Wing Nuts.

For license brackets, are handy devices especially where license plates are removed from time to time. The leather and steel lockwashers insure against loss when screwed up tight.

Wing nuts.

Assorted Nuts, Washers, Pins, Etc.

A good way to purchase this material is in assortments, which consist of one box each of the following assorted articles: cap screws, taper pins, cotter pins, hex nuts and lock washers. This makes a very convenient assortment and is especially popular among garage men and repair shops. The five boxes are neatly packed in strong cardboard box and retails for $1.50. (Stevens Co., 375 Bdw'y N.Y.)

---

*Manufacturers of aluminum pistons: Green Engineering Co., Dayton, Ohio, Butler Manufacturing Co., Indianapolis, Ind.; McQuay-Norris Co., St. Louis, Mo. *Ford cylinders are 3¾" bore but will stand about 3/32" larger bore. Aluminum pistons are supplied in sizes from 3¾ to 1/32" larger only.

CHART NO. 247-BB—Pistons. Rings. Valves. Copper Terminals. License Brackets. Wing Nuts—(also see Ford Instruction.)

See pages 651 and 643, "Piston and Piston Clearance." and page 654, "Piston Rings."

Money Making Additions To a Garage.

Rectifiers for charging storage batteries, see pages 465, 463 and 864-K.

Motor-generator sets for charging storage batteries, see pages 462 and 864-L.

Decarbonizing outfit; see pages 624, 726, 727.

Oxy-Acetylene outfit; see pages 727, 726, 720.

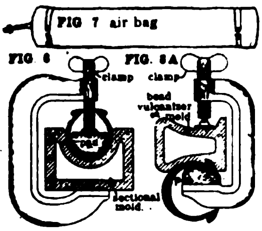
Air compressor outfit per page 564.

Cylinder reboring machine, a profitable **investment**, see pages 653, 654, 616. **See also Top Repairing**, page 847.

Tire repairing is one of the **best** investments, **see** page 574 and below.

Vulcanizers, Tools and Tire Repair Material.

There are two methods of preparing a tire to vulcanize; the "sectional" method as explained on page 573 and the "wrapped tread" method as per page 575.



When the sectional method is used there are two methods of holding tire in the mold; by a "clamp" as per fig. 8 and by an "air bag" as per fig. 7, and fig. 29, page 574, which expands the tire.

There are also two methods of repairing side-wall and bead repair; by use of "air-bag" and a "bead mold" per fig. 29, page 474, and by use of a "clamp" and "bead mold," per fig. 8A.

The electric vulcanizer, fig. 11, and the Shaler steam vulcanizer; fig. 2, page 574, vulcanizes a tire repair by the "wrapped tread" method as per page 575. Air bags are not used, but inside molds are inserted for inside repairs and outside molds, or hot plates for outside repairs.

A Sectional Steam Vulcanizer.

The model 6 F (A. K.) vulcanizer, fig. 30, suitable for small repair shops in towns where there are a fairly good number of 4½" and 5" tires, vulcanizes by the "sectional" method with which air bags are used. Steam is generated in boiler B, by gas or gasoline fuel connected at (G).

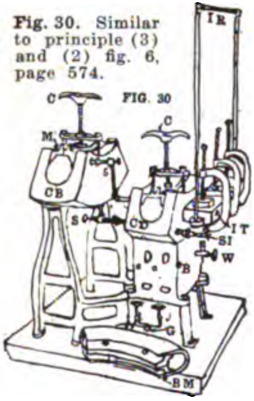


Fig. 30. Similar to principle (3) and (2) fig. 6, page 574.

There are two cavity molds, CB for 4½", 5" tires and CD for 4", 3½" tires. Tires 3" size can be vulcanized by placing the 3" mold BM in the mold CD. These molds will vulcanize "inside" and "outside" of tire also "side wall" and "bead" repairs. See fig. 29, page 574, and note the bead mold, also M, fig. 30.

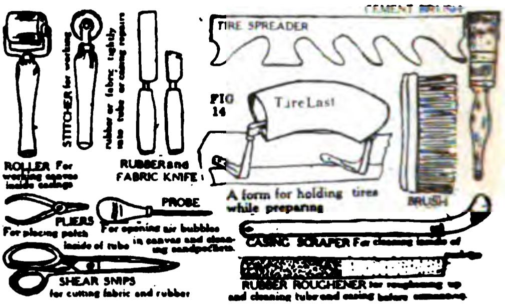
After tire is prepared to be vulcanized (see page 573) an air bag is inserted, then placed in mold CB. Air bag is then inflated to 50 lbs. pressure, clamp C applied and steam turned into mold at S.

Where there is considerable repairing the **inside repair mold or patch** (4) fig. 6, page 574 is used. This is also handy for thoroughly drying out tires before vulcanizing.

Inner tubes are vulcanized by placing over rack (1 R) and part to be vulcanized is placed on plate (1 T) through which steam passes.

Cost of Tire Repair Outfit.

1, model 6F vulcanizer (fig. 30)	$245.00
5, airbags, 3" to 5" x 16" long	22.70
1, gal. No. 1086 vul. cement	2.40
1, qt. No. 1043 cold patching cement	.67
1, lot inner tube valve patches	1.50
5, lbs. *tread stock (cures gray)	5.00
10, lbs. *tread stock (cures black)	10.00
5, lbs. inner tube *repair stock (red)	7.50
2, lbs. inner tube *repair stock (gray)	3.00
2, lbs. inner tube *repair stock, cured on one side only, for inside reinforcement	3.00
5, lbs. cushion stock	6.25
5, lbs. breaker-strip fabric	6.25
5, lbs. bead cover fabric	10.00
10, lbs. carcass fabric	15.00
5, lbs. carcass fabric frictioned one side only, for last ply next to tube and reinforcements	11.25
1, lot asst'd sizes Schrader valves, inner valves, valve caps, soapstone, waxed paper	7.50
1, lot tire tools per illustration**	7.50
Total	$364.52


CEMENT BRUSH
TIRE SPREADER
STITCHER for working rubber or fabric tightly into tube or casing repairs
ROLLER For working canvas inside casings
RUBBER and FABRIC KNIFE
FIG 14
Tire Last
A form for holding tires while preparing
BRUSH
PROBE
PLIERS For placing patch inside of tube
For opening air bubbles in canvas and cleaning sandpockets.
CASING SCRAPER For cleaning inside of casings
SHEAR SNIPS for cutting fabric and rubber
RUBBER ROUGHENER for roughening up and cleaning tube and casing before cementing.

Tire repair tools for a small shop. One can practice on old tires to acquire experience. **Learn the construtcion of tires, as explained on **pages** 565, 564, 573, 574, 559.

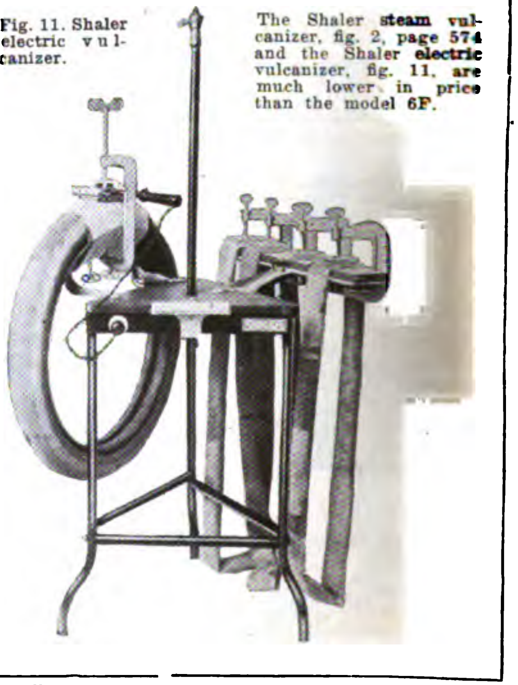


Fig. 11. Shaler electric vulcanizer.

The Shaler **steam** vulcanizer, fig. 2, **page 574** and the **Shaler electric** vulcanizer, fig. 11, **are** much lower in **price** than the model **6F**.

HART NO. 247-C—Money Making Additions For The Garage.

Means vulcanizing rubber. ****Other necessary tools are**: heavy hammer and tire irons for **removing tires**, "4 in 1" valve tool per fig. 5, page 568. Air pump, also a buffer for cleaning carcass of tire after **old rubber** has been cut away. See also fig. 20, page 735. See also page 611.

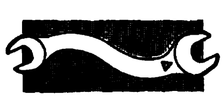


Fig. 1—The popular S-wrench.

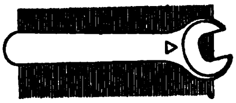


Fig. 2 — Engineers' single head wrench.

Fig. 3 — Double head engineers' wrench, machinists type.

Socket type wrench with bent handle.

TABLE NO. 96.

First and fourth columns give the trade number of William's wrenches and those sizes marked are ones most used for auto work.*

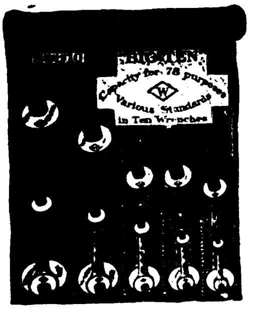
Second and fifth columns give the actual diameters of the body of the bolts and cap screws.

Third and sixth columns give the milled (or actual) opening size of wrench at each end and are the sizes suitable for the heads and nuts with allowance for an easy fit.

Number	For U. S. Standard Nuts Size Bolts	Openings Milled	Number	For Hexagon Head Cap Screws; Diameter Screws	Openings, Milled
21	1/8 & 3/16	5/16 & 13/32	•721	1/8 & 3/16	5/16 & 3/8
22	1/8 & 1/4	5/16 & 1/2	722	1/8 & 1/4	5/16 & 7/16
•23	3/16 & 1/4	13/32 & 1/2	723	3/16 & 1/4	3/8 & 7/16
24	3/16 & 5/16	13/32 & 19/32	723A	3/16 & 5/16	3/8 & 1/2
25	1/4 & 5/16	1/2 & 19/32	725	1/4 & 5/16	7/16 & 1/2
26	1/4 & 3/8	1/2 & 11/16	•725A	1/4 & 3/8	7/16 & 9/16
•27	5/16 & 3/8	19/32 & 11/16	•725B	5/16 & 3/8	1/2 & 9/16
28	5/16 & 7/16	19/32 & 25/32	726	5/16 & 7/16	1/2 & 5/8
•29	3/8 & 7/16	11/16 & 25/32	727	3/8 & 7/16	9/16 & 5/8
30	3/8 & 1/2	11/16 & 7/8	728	3/8 & 1/2	9/16 & 3/4
31	7/16 & 1/2	25/32 & 7/8	•729	7/16 & 1/2	5/8 & 3/4
•32	7/16 & 9/16	25/32 & 31/32	730	7/16 & 9/16	5/8 & 13/16
•33	1/2 & 9/16	7/8 & 31/32	731	1/2 & 9/16	3/4 & 13/16
34	1/2 & 5/8	7/8 & 1 1/16	731A	1/2 & 5/8	3/4 & 7/8
35	9/16 & 5/8	31/32 & 1 1/16	•731B	9/16 & 5/8	13/16 & 7/8
36	9/16 & 3/4	31/32 & 1 1/4	732	9/16 & 3/4	13/16 & 1
37	5/8 & 3/4	1 1/16 & 1 1/4	733	5/8 & 3/4	7/8 & 1
•38	5/8 & 7/8	1 1/16 & 1 7/16	734	5/8 & 7/8	7/8 & 1 1/8
39	3/4 & 7/8	1 1/4 & 1 7/16	735	3/4 & 7/8	1 & 1 1/8
40	3/4 & 1	1 1/4 & 1 5/8	736	3/4 & 1	1 & 1 1/4
41	7/8 & 1	1 7/16 & 1 5/8	•737	7/8 & 1	1 1/8 & 1 1/4
42	7/8 & 1 1/8	1 7/16 & 1 13/16	738	7/8 & 1 1/8	1 1/8 & 1 3/8
43	1 & 1 1/8	1 5/8 & 1 13/16	739	1 & 1 1/8	1 1/4 & 1 3/8
44	1 & 1 1/4	1 5/8 & 2	739A	1 & 1 1/4	1 1/4 & 1 1/2
45	1 1/8 & 1 1/4	1 13/16 & 2	739B	1 1/8 & 1 1/4	1 3/8 & 1 1/2

*The above list is the Williams double head open end wrench per fig. 8 above. *Numbers 21 to 45 will fit U. S. standard nuts and bolt head.

*Numbers 721 to 789B will fit cap screw heads; U. S. or S. A. E.



Garage Wrench Set.

Williams "Big 10" wrench assortment for general automobile work—illustrated to the left and tabulated as to sizes below. Note it is a recommended assortment taken from the above list (table 96). The St. Louis Machinist Supply Co., St. Louis, carry full line of these wrenches—also other Supply Houses.

"EXTRA CAPACITY" GARAGE, ETC. (See Table) SET, "BIG TEN," No. 10

No.	U. S. Nuts Dia. Bolts Small Head	U. S. Nuts Dia. Bolts Large Head	U. S. Cap Scs Dia. Screws Small Head	U. S. Cap Scs Dia. Screws Large Head	S. A. E. Standard Nuts and Cap Screws	A. L. A. M. Standard Nuts and Cap Screws	Openings Milled	PRICE Unfinished	PRICE Semi-finished	PRICE Finished
721	1/8		1/8	3/16		1/4	5/16&3/8	$.12	$ 17	$ 26
23	3/16	1/4		5/16	5/16	5/16	13/32&1/2	.14	21	.32
725A			1/4	3/8	1/4&3/8	3/8	7/16&9/16	.17	.25	.38
27	5/16	3/8				7/16	19/32&11/16	21	.31	.46
729			7/16	1/2	7/16&1/2	1/2	5/8&3/4	.25	.37	.56
731B		1/2	9/16	5/8	9/16	9/16	13/16&7/8	.30	.45	.68
32	7/16	9/16					25/32&31/32	.37	.55	.85
33C				3/4	5/8&11/16	5/8&11/16	15/16&1	.37	55	.85
737		3/4	7/8	1	7/8	3/4&7/8	1 1/8&1 1/4	.66	96	1.40
38	5/8	7/8			3/4&1	1	1 1/16&1 7/16	1.00	1 40	1.90
No. 10 Set			List Price of Roll, $.60 extra					3 59	5 22	7.66

Open End Wrenches.

Probably the most abused, least considered and yet the most indispensable tool in the kit of the mechanic is the wrench, the solid open-ended wrench, known to the British mechanician as the fixed spanner and known in the United States as the machinists' wrench.

Of the many kinds of wrenches, the cheapest, strongest, most efficient and most durable is the open end wrench. This style of wrench varies in quality and price in the following order; gray iron castings, malleable iron castings, sheet steel stamped and steel drop forgings. The drop forged wrench is superior. See illustrations for proper name of the popular type of open-end wrenches.

Open end wrenches are used on cap screws, bolt heads and nuts.

They may be divided into two general classes, the **U. S. S.** and **S. A. E.** The only difference between them is the width of opening between the jaws.

A standard wrench for a ½" U. S. S. bolt will not fit a ½" S. A. E. cap screw and vice versa.

The S. A. E. wrenches are usually of the "**cap screw size**" and the U. S. S. wrenches are of the "**U. S. S. bolt and nut size.**" Table 96 explains and also gives the various sizes for automobile work. The head is always larger on a U. S. S. bolt than on a cap screw.

Markings — Wrenches are usually marked with the size on each end. They are also marked with the manufacturers number, this number is an indication to its size, see table 96.

Probably the most universally used wrench is the Williams wrench, as per table 96.

How to find the size wrench to fit an S. A. E. cap screw head. See table 97, chart 247-DD.

How to find the size wrench to fit a standard bolt and nut—see table 98, chart 247-DD, or refer to table 96 on this page for additional information.

Fig. 13 — **Waldens No. 100 thin wrench set for close places, check nuts, etc. Sizes are:** 1; ⅞; ¾; ⅝; 9/16; ½; 7/16; ⅜; 5/16; and ¼ inch (actual width of opening—Walden Co., Worcester, Mass.)

Fig. 55—Williams spark plug wrench; No. 993, socket end fits ⅞ and ½ inch spark plug with ⅞ in. hex. and ½ in. U. S. standard nut. Open end fits ⅜ in. S. A. E. nut or screw and ⅜ in. U. S. S. cap screw (9/16 actual opening). **No. 994** size, socket end fits spark plugs with 1in. hex. Open end is ⅞ in. actual opening.

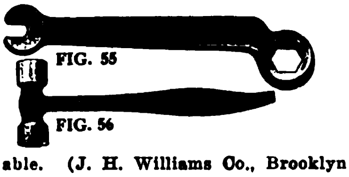


FIG. 55

FIG. 56

Fig. 56 — **Williams demountable tire tool; socket wrench to fit rim bolt nuts and hammer combined.** Very serviceable. (J. H. Williams Co., Brooklyn N. Y.)

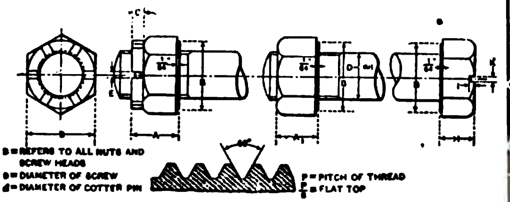
CHART NO. 247-D—Flat Wrenches for U. S. S. Bolts and Nuts and S. A. E. Bolts and Cap Screws—see also page 238 and chart 285.

TABLE 97.

*S. A. E. Cap Screw and Bolt Sizes.

This table gives the diameter of cap screw (D); **threads per inch (P)** (also see chart 285); **thickness of head (A-1); di. across flats of nut or head—where wrench fits (B); size of drilled hole for cotter pin for castellated nut (E)—(see chart 285 for castellated nut); depth of slot in head (I); width of slot (K); di. of cotter pin (d).**

To find the size tap and drill to use for S. A. E. cap screws and bolts, see chart 285-B—table 102.


B = REFERS TO ALL NUTS AND SCREW HEADS
D = DIAMETER OF SCREW
d = DIAMETER OF COTTER PIN
60°
P = PITCH OF THREAD
P/8 = FLAT TOP

D	1/4	5/16	3/8	7/16	1/2	9/16	5/8	11/16	3/4	7/8	1	1 1/8	1 1/4	1 3/8	1 1/2
P	28	24	24	20	20	18	18	16	16	14	14	12	12	12	12
A	9/32	21/64	13/32	29/64	9/16	39/64	23/32	49/64	13/16	29/32	1	1 5/32	1 1/4	1 13/32	1 1/2
A_1	7/32	17/64	21/64	3/8	7/16	31/64	35/64	19/32	21/32	49/64	7/8	63/64	1 3/32	1 13/64	1 5/16
B	7/16	1/2	9/16	5/8	3/4	7/8	15/16	1	1 1/16	1 1/4	1 7/16	1 5/8	1 13/16	2	2 3/16
C	3/32	3/32	1/8	1/8	3/16	3/16	1/4	1/4	1/4	1/4	1/4	5/16	5/16	3/8	3/8
E	5/64	5/64	1/8	1/8	1/8	5/32	5/32	5/32	5/32	5/32	5/32	7/32	7/32	1/4	1/4
H	3/16	15/64	9/32	21/64	3/8	27/64	15/32	33/64	9/16	21/32	3/4	27/32	15/16	1 1/32	1 1/8
I	3/32	7/64	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8	1/8	7/32	7/32	1/4	1/4
K	1/16	1/16	3/32	3/32	3/32	3/32	3/32	3/32	3/32	3/32	3/32	5/32	5/32	3/16	3/16
d	1/16	1/16	3/32	3/32	3/32	1/8	1/8	1/8	1/8	1/8	1/8	11/64	11/64	13/64	13/64

All dimensions in inches.

**Spark Plug Wrench.

No. 1. The ⅞ inch end of this wrench fits all standard spark plugs, such as the Spitfire, Reliance, Rajah, Red Head and many others, while the 1 inch end fits the Sootless, Reliance, ⅞ in. Hers, Bosch and others.

No. 2. The 1⅛ inch end fits all standard spark plugs of the large hex type such as the Champion, De Luxe, and others. (Stevens Co, N. Y.)

S. A. E. Spark Plug Shell Sizes.

The illustrations to the right, show the two S. A. E. spark plug shells. It will be noticed that the diameter of the hexagon part of shells differ. The "small hex." measures ⅞ inch across the flat and the "large hex." measures 1⅛ inch. Reference to table 96, chart 247D, will show that the No. 734 wrench will fit both sizes.

S. A. E. spark plugs—are all ⅞—18, meaning that the outside diameter is ⅞ inch and there are 18 threads to the inch. See page 238 for difference in spark plug threads and explanation of spark plug sizes. **Gaskets must be used** with the S. A. E. spark plugs. See pages 239 and 607 for size gaskets to use.

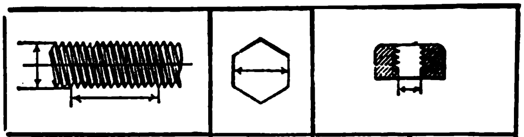
Note table 102, chart 285-B—a ⅞ S. A. E. plug requires a special tap cutting 18 threads—whereas the standard S. A. E. ⅞ thread is 14 threads to the inch.

TABLE 98.

U. S. Standard Bolt Size; Head and Nut.

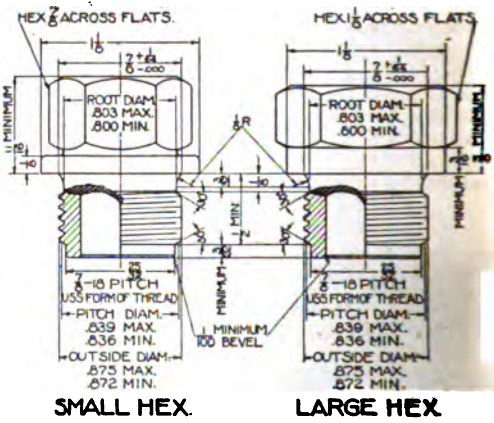
This table gives—(first column), di. of **bolt or screw**; (second column), **threads per inch**; **(third column)**, di. across **head**; **(fourth column) size** of hole in thousandth of an inch; **(fifth column)**, size drill to use for tapping hole (**see also chart** 285-B).

Mill means the "milled size" of **head of screw** or bolt or the opening in an open end **wrench**.



Diameter of Tap.	Threads per Inch.	Mill	Exact Size of Hole.	Tap Drill Used.
1/4	20	1/2	.1910	[illegible]
5/16	18	19/32	.2403	[illegible]
3/8	16	11/16	.2938	[illegible]
7/16	14	25/32	.3447	[illegible]
1/2	13	7/8	.4001	[illegible]
9/16	12	31/32	.4542	[illegible]
5/8	11	1 1/16	.5069	[illegible]
3/4	10	1 1/4	.6201	5/8
7/8	9	1 7/16	.7307	[illegible]
1	8	1 5/8	.8376	[illegible]
1 1/8	7	1 13/16	.9394	[illegible]
1 1/4	7	2	1.0644	1 1/16
1 3/8	6	2 3/16	1.1585	[illegible]
1 1/2	6	2 3/8	1.2835	[illegible]
1 3/4	5	2 3/4	1.4902	[illegible]
2	4 1/2	3 1/8	1.7113	[illegible]
2 1/4	4 1/2	3 1/2	1.9613	[illegible]
2 1/2	4	3 7/8	2.1752	2 3/16
2 3/4	4	4 1/4	2.4252	2 7/16
3	3 1/2	4 5/8	2.6288	[illegible]

S. A. E. STANDARD SPARK PLUG SHELL



SMALL HEX. LARGE HEX.

ALL DIMENSIONS BELOW SHOULDER ARE IDENTICAL FOR BOTH SPARK PLUG SHELLS

A well assorted set of screw dies and taps, cutting the U. S. and S. A. E. standard threads, manufactured by Greenfield Tap & Die Corp., Greenfield Mass.

Set No. 310: ¼, 5/16, ⅜, 7/16, ½ U. S. S. and ¼, 5/16, ⅜, 7/16, ½ S. A. E..........**$18.00**

Set No. 311: ¼, 5/16, ⅜, 7/16, ½, 9/16, ⅝, ¾, Both U. S. S. and S. A. E........... **27.00**

CHART NO. 247-DD—S. A. E. and U. S. Standards of Screw and Bolt Sizes. S. A. E. Spark Plug Sizes. Spark Plug Wrenches—see charts 285 to 286-B, for threads, taps, dies, drills, etc.

---

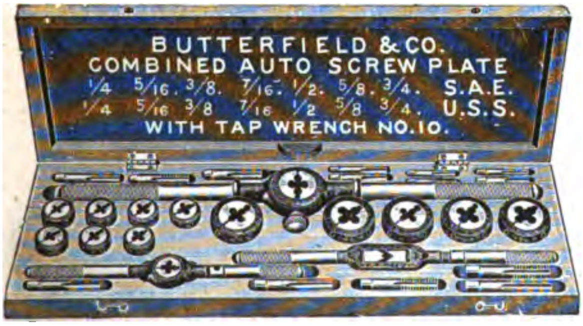
*The diameter of bolts and cap screws is one-one thousandth of an inch less than nominal diameter.

**See also page 611.

Starrett socket, ratchet wrench set; there are 28 hexagon steel sockets in this set varying by thirty seconds; from 5/16 in. to 1¼ in.

This type of wrench set is probably one of the most useful set of tools a repairman could possess. With this set a repairman can remove or tighten nuts in inaccessible places which would otherwise require the removing of many parts to reach the nuts with an ordinary wrench. The nuts can be loosened or tightened at various angles. The time saved alone would soon pay for the set.

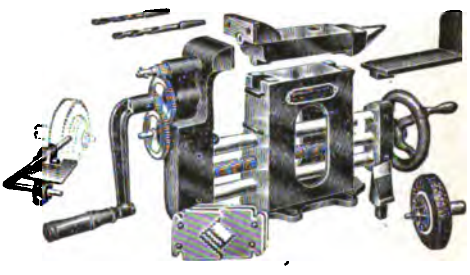
In addition it is fitted with a drilling attachment which will drill in inaccessible places on the car, and will hold any size of twist drill from ⅛ to ½ inch.


BUTTERFIELD & CO.
COMBINED AUTO SCREW PLATE
1/4 5/16. 3/8. 7/16. 1/2. 5/8. 3/4. S.A.E.
1/4 5/16 3/8 7/16 1/2 5/8 3/4. U.S.S.
WITH TAP WRENCH NO.10.

Butterfield screw plate set consists of: 4 dies and collets, 1⅝ in. diameter, cutting ¼28, 5/16 24, ⅜24, 7/16 20; 3 dies and collets, 2¾ in. diameter, cutting ½20, ⅝18, ¾16; 7 plug hand taps, S. A. E. Standard; 4 dies and collets, 1⅝ in. diameter, cutting ¼20, 5/16 18, ⅜16, 7/16 14: 3 dies and collets, 2¾ in. diameter, cutting ½13, ⅝11, ¾ 10; 7 plug hand taps, U. S. Standard, 1 stock 14 in. long 1 stock 26 in. long, adjustable tap wrench No 10, (Butterfield Co., Derby Line, Vermont, Manufacturers.)

Walden-Worcester Wrenches. No. 12 combination socket wrench set: contains: 1 rachet wrench 9 ins.; 3 extension bars; 1 universal joint; 1 tee and offset-wrench; 27 hex sockets; 11 square sockets; 1 spark plug socket; 5 open end wrenches; 1 brace socket wrench. Price $12.00.

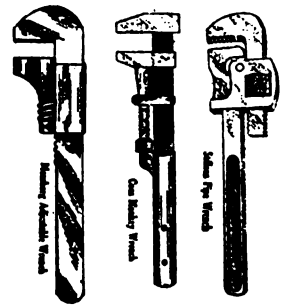
No. 1005.—Yankee bench drill. Has two feeds, friction for rapid movement and ratchet to feed drills. Table has vertical adjustment on bracket. Chuck holds up to ½ in. Die table is 6¾ in., length 28 in., wgt. 29 lbs. North Bros. Mfg. Co., Philadelphia, Pa.



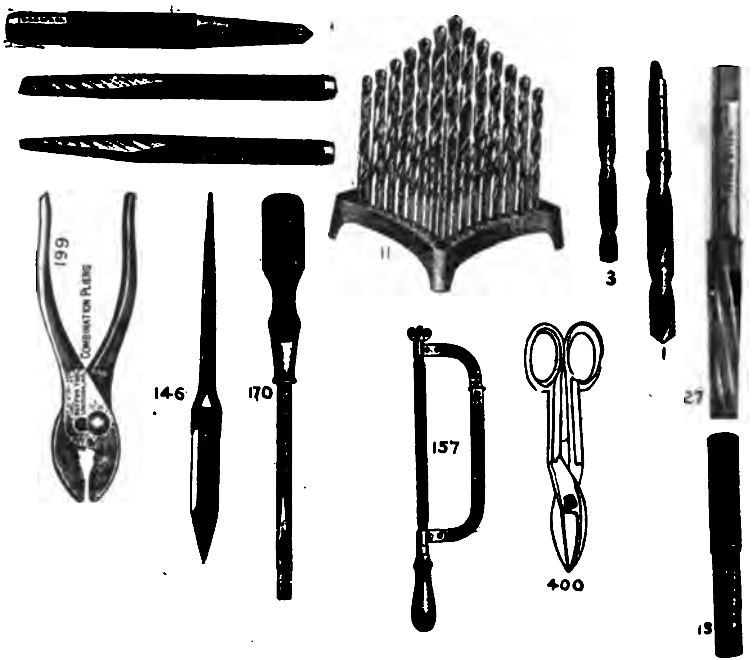
The Stewart handy worker is a tool which combines several practical working devices in compact form; an **anvil, drill press** and a **grinding wheel.** The manufacturers are: Chicago Flexible Shaft Co., LaSalle and Ontario St., Chicago, Ill.

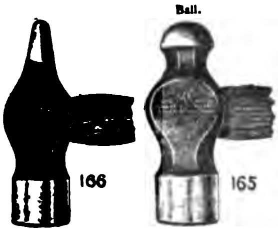
CHART NO. 247-E—*Socket Wrenches. Tap and Die Set. Bench Drill Press. Combination Vise.
See charts 285 to 285-B for U. S. and S. A. E. Threads etc.

***See also chart 306.**

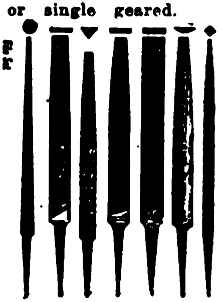


Three kinds of wrenches which ought to be in every repair shop.





Breast drill — double or single geared.



Files — as follows: round, flat, three corner, flat bastard, mill bastard, half round bastard, square bastard.

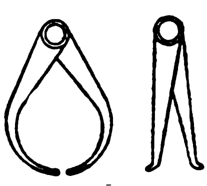


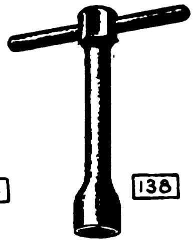
Fig. 4—Plain calipers—for spring type see page 700.

A Selection of Small Tools.

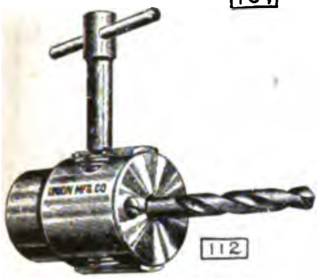
*1—Tap and die set (chart 247E) for thread cutting, S. A. E. and U. S. Standard ¼ to ¾ inch..............$18 to	$48.00
†1—Pipe size tap and dies ⅛ to ½ inch, U. S. Standard......	7.50
1—Stand or rack for holding small drills....................	1.50
*1—Set of straight shank drills (1/16 to ½ in. by 32nds)......	5.00
1—Set of taper shank drills (for drill press use)............	8.00
1—Set of taper reamers ¼, ⅜ and ½ inch (for use in a brace)..	1.50
1—Pair of tinners snips	1.25
1—Adjustable hack saw frame with one dozen 10 inch blades..	1.50
1—Each 3, 6 and 10 inch screw drivers..................	1.25
1—Set of open end wrenches—"Big Ten," see chart 247-D (milled openings suitable for general work).............	7.50
1—Set of thin end wrenches, see chart 247-D, (for check and lock nuts) ¼ to 1 inch openings..........................	1.50
2—Combination spark plug wrench No. 1 and No. 2 (will fit all makes)	.50
1—14 inch Coes monkey wrench	.50
3—Stillson wrenches for pipe work, 6, 10 and 14 inches......	5.00
1—Thin automobile wrench	.75
2—Adjustable S wrenches 6 and 8 inches................	1.75
1—Pair of nickeled auto pliers..........................	.50
1—Breast drill (double geared)...........................	3.50
1—1 lb. machinists hammer	.75
1—4 oz. riveting hammer	.50
1—Heavy engineers hammer (with flat and round face)........	1.50
2—Center punches	.50
1—Set of cold chisels ¼ to ¾ inch......................	1.25
2—Cape chisels ¼ and ½ inch	.50
2—1 lb. soldering coppers...............................	1.50
**2--8 inch calipers (inside and outside)...................	.50
1—Assortment of files, about 3 each, flat, round, half round, triangular and square.....................................	3.00
1—File card (fine wire brush for cleaning files).............	.50
**A-General assortment of useful tools such as a crow-bar or pinch-bar, brace, drifts, (key and pin) socket wrenches spring dividers, counter sinks, spirit level, ladle (for melting metals), blow torch, gas pliers, electricians pliers, rule, gauges (such as pitch, thickness, wire, tap, and drill) sledge hammer, putty knife, scriber, scraping tools, square, spanner wrench etc., approximately..........................	30.00
Total..................................	$137.50

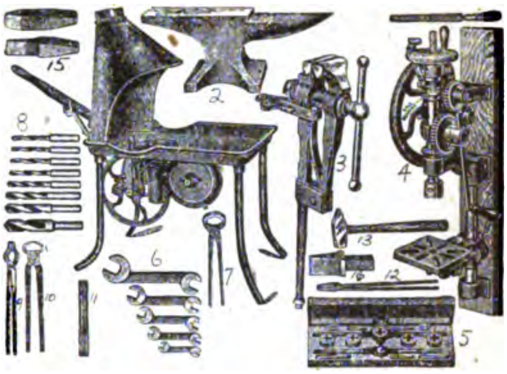
*See charts 247-DD, and E. †See chart 247-B.
**For measuring tools and how to use them, see charts 283 to 284.

ART NO. 247-F—A Selection of Small Tools, Giving Approximate Prices and Sizes—See charts 285 to 286-B for drill sizes, taps, dies etc.



LEFT HAND CUT OFF TOOL
RIGHT HAND CUT OFF TOOL
104





*Lathe Tools.

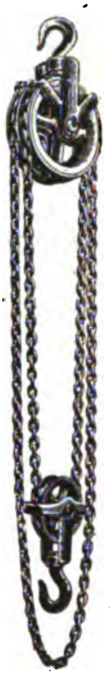
1—5 inch, 3 jaw geared scroll chuck	$ 9.00
1—socket wrench ⅜, ½ and ⅝ . .	1.60
1—set of 4 in. "lathe tool holders" to be used with 14 inch lathe	5.40
1—2 jaw drill chuck with No. 1 or 2 arbor to hold drills up to ½inch (see chart 286-A.).	5.65
3—lathe dogs, ½, 1, 1½ inch each	.85

Blacksmith Equipment.

1—anvil, 50 to 100 lbs.
1—forge, with 12 in. fan, 25x36 hearth.
1—post drill, run of spindle 8½ inches. and drill to 1¼ inch hole.
1—set drill bits ⅛, 5/16, ¼, 5/16, ⅜, ⅞, ¾ inch.
1—screw plate—see charts 247-DD and E.
1—vise 50 lb. (blacksmith).
1—set of wrenches (Big 10, chart 247-D).
1—Flat lip tongs.
1—8 lb. hammer.
2—pair cutting nippers.
Above outfit of blacksmith equipment can be had for about $52.00.

Other Shop Necessities.

1—1 ton chain block...........	$17.50
1—blow torch	5.00
1—4-inch solid jaw machinists vise (swivel base)	8.50



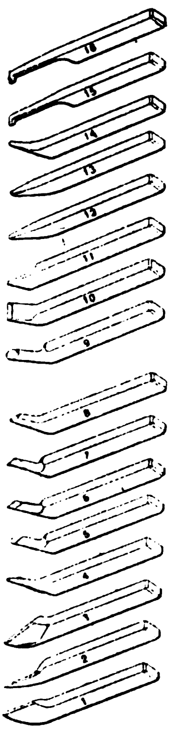
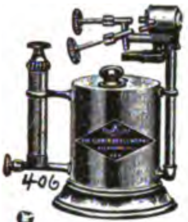
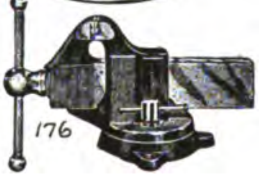


Fig. 5—Hand forged lathe tools—a complete assortment. (Also see chart 289.)





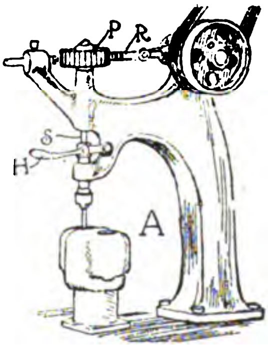


Fig. 6—Where there is a great deal of valve grinding a special machine is necessary.

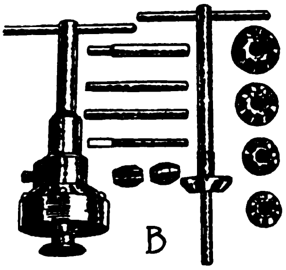


Fig. 7—A valve and valve seat refacing outfit is necessary.

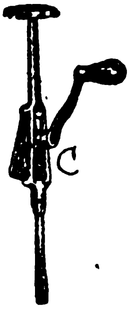


Fig. 8—A hand valve grinding tool with reciprocating motion.

HART NO. 247-G—Lathe Tools. Blacksmithing Outfit. Other Shop Tools. Valve Grinding Tools.

See chart 289 "How to Make Lathe Tools." See pages 516 and 631 for "Valve Grinding Tools."

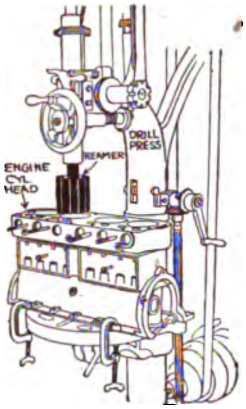


Fig. 1—Cylinder reboring reamer: Designed for attaching to a drill press. Suitable for Ford cylinders. (Stevens & Co., 375 Broadway, New York.)

This new reamer was designed to enable the small auto dealer and repairman to rebore the cylinders of Ford cars and fit new 1/32 inch over-size pistons which are now furnished by the Ford factory.

The reamer is built up with inserted blades and fitted with a No. 4 Morse taper shank. It can be used in any ordinary drill press which is geared down to run about 30 rev. per min.

The time required is about 15 min. per cylinder and the finish is in every way equal to the original factory job—which, as a matter of fact, is accomplished in practically the same manner.

The reamer can be reground to its original dimensions at slight cost and any special size of body or Morse shank can be furnished to order.

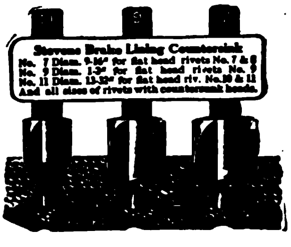

Stevens Brake Lining Countersink
No. 7 Diam. 9-16" for flat head rivets No. 7 & 8
No. 9 Diam. 1-2" for flat head rivets No. 9
No. 11 Diam. 13-32" for flat head riv. No. 10 & 11
And all sizes of rivets with countersunk heads.

Fig. 3—Stevens brake lining countersinks are designed to cut a clean, even hole in any style of clutch or brake lining. The shank is 5/16 inch diameter and works satisfactorily in either a hand drill or power press. Furnished singly or in complete sets of the three sizes mentioned.

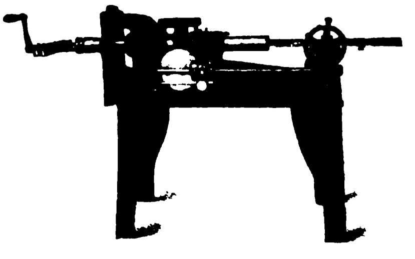
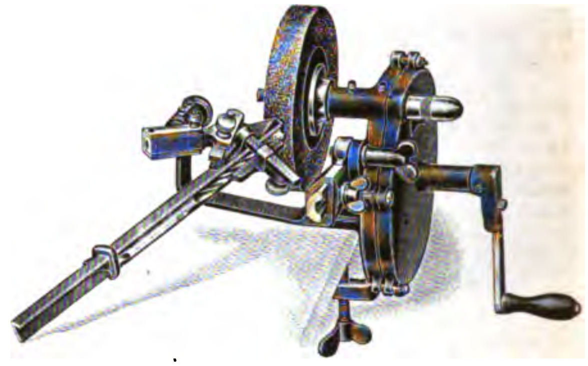


Fig. 2—*Cylinder reboring machine. Re-bores scored, glazed and welded cylinders, or those worn out of true. Successfully rebores any size or type of engine block from 1 to 12 cylinders, and from 3 to 8 inches in diameter. Rebores any ordinary 4 cylinder block in less than 2 hours, and with an accuracy down to the fractional part of a thousandth of an inch. (Marvel Machine Co., 307 Thirteenth Ave., Minneapolis, Minn.)



A fast-cutting, powerful grinder for sharpening twist drills, chisels and all shop work, is shown above. Note the drill grinding attachment. Mnf'g'd by American Grinder Mfg. Co., Milwaukee, Wisconsin.

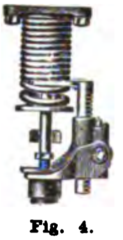


Fig. 4.

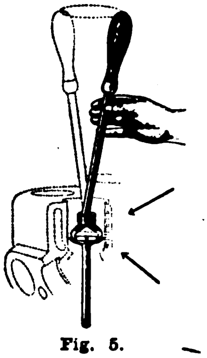


Fig. 5.

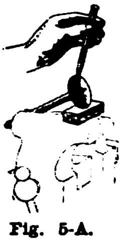


Fig. 5-A.

Fig. 4—"Bryant" valve spring compressor. The upper engaging device is inserted between the coils, thereby raising the spring away from the disc, leaving the disc and key free to be removed. The valve may be "ground in" and replaced in position without removing spring or lifter from their places. See also page 681.

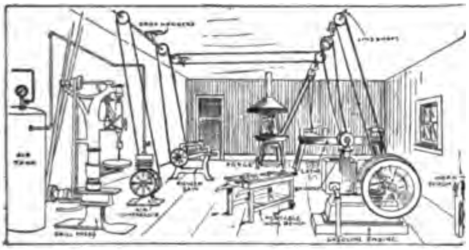
Fig. 5—"Anderson" universal valve grinder. To use this tool it is necessary to make two light impression or center punch marks on the flat surface of the valve, (fig. 5-A), at an angle, or in the sides of the holes already there. The "pinching-bug" hardened steel jaws are then inserted, and securely held by turning down knurled nut. Grind by rotating between the palms of the hand. The rod is fastened in such a way so as to give a swivel action, permitting the rod to be held at any angle while grinding—the valve remaining true on its seat. (Stevens & Co.)

CHART NO. 247-H—Cylinder Reaming and Reboring Machines. Brake Lining Countersinks. Valve Grinding Tool. Valve Spring Compressor.

*See page 653, Instruction 46, Reboring, Grinding and Reaming Cylinders. See also advertisement in back of this book for a **Reboring Attachment** for South Bend Lathes.

Machinery Equipment.

The machinery equipment, together with list of machinery is given in chart 248. This can be added to or parts left out as desired. This chart only offers suggestions.



The line shaft as shown in chart 248 would probably be arranged different. It is shown in one length, but likely would be arranged in two sections or more.

Approximate Cost of Shop Equipment.

Machinery shown in chart 248 will cost approximately	$600.00
Lathe tools (chart 247-G)	25.00
Large tools (chart 247-G)	45.00
Small tools (chart 247-D E, F.)	50.00
Wash rack	8.00
Other tools as files, and various small material	22.00
Total	$750.00

The air compressor outfit is important. The air pump could be operated from the line shaft or by an electric motor, see chart 237-B.

Other Money Making Equipment.

Small vulcanizing outfit (chart 247-C)	$ 60.00
Rectifier for charging ignition batteries (chart 247-C)	32.00
Oxygen carbon removing outfit (chart 298D.)	15.00
Oxy-acetylene welding outfit (chart 298D).)	80.00
Total	$187.00

Power to run the machinery should be installed—either a gasoline engine or an electric motor. If electric motor, this is usually rented from the electric company.

The work benches are usually placed along the repair shop walls next to the windows (chart 243, fig. 8), and the vise is attached to one of them, while the remainder of the tools are so arranged as to leave sufficient space for the automobile undergoing repair. The work bench is most necessary and should be placed where there is plenty of light. It should measure no less than 8 or 10 feet long, 2 inch thickness of well seasoned pine, or better, birch. Height about three feet. Width about 2 feet 6 inches.

**Lathes Suitable for Repair Shop Work.

Make	Swing	Length	Swing over carriage	Swing over bed	Cone	Hole in spindle	Threads	Counter shaft speed	Gear ratio	Between centers	Price
Flathers	16"	6' to 16'	10"	17"	1 step	1⅜	2 to 72	180 r.p.m	......	...	.....
Springfield	14"	6'	9½"	15"	"	1 1/16	2 to 36	150 r.p.m	11 to 1	34"	$585.
Barnes	13"	6'	12"	...	"	1⅝	1 to 56	200 r.p.m	9¼ to 1	32"	177.
Bradford	16"	8'	10⅝"	16¼"	"	1⅜	8 to 46	200 r.p.m	......	25½"	875.
*Sebastian	15"	6'	9½"	15"	"	1 5/16	......	190 r.p.m	......	40"	.....
South Bend	15"	6'	10⅝"	15¼"	"	1⅛	......	200 r.p.m	......	28"	.....
Davis	14"	6'	9½"	15"	"	1⅛	1½ to 40	200 r.p.m	10 to 1	38"	....
Champion	16"	6'	11⅝"	17⅛"	"	1⅝	2 to 56	...	9 to 1	30"	264.

*Also made with gap bed without extra charge. Gap 7¾ inch long and 3½ inch deep, increasing swing in gap 7 inches. Carriage runs over gap without letting down. (see chart 248.)

Address of mfgr's. of lathes: Flather & Co., Inc., Nashua, N. H.; W. F. and J. Barnes Co., Rockford, Ill.; Sebastian Lathe Co., Cincinnati, Ohio; Davis Machine Tool Co., Rochester, N. Y.; Springfield Mch. Tool Co., Springfield, O.; Bradford Mch. Tool Co., Cincinnati, O.; South Bend Lathe Wks., South Bend, Ind. (see adv. back of book); Champion Tool Wks. Co., Cincinnati, O.

Power Hack Saws.

	Capacity	Stroke	Price	Made by
Universal	6" x6"	7" quick return...	$50.	The West Haven Mfg. Co., New Haven, Conn.
Star	4½"x4½"	.. self feeding...	$25.	Millers Falls Co., Millers Falls, Mass.
Goodell-Pratt	4½"x4½"	.. automatic stop.	80	Goodell-Pratt Co., Greenfield, Mass.

Chain Hoists.

Peerless. Differential hoist, ¼ ton $18. ½ ton $21. 1 ton $28. Standard lift 8 ft.

Wright. Differential hoist, ¼ ton $18. ½ ton $21. 1 ton $28. Lift 6, 7 and 8 ft. respectively

Address of mfgr's. of chain hoists: The Peerless is mfgd. by Edwin Harrington Son & Co., Phila., Pa.; The Wright is mfgd. by Wright Mfg. Co., Lisboro, Ohio.

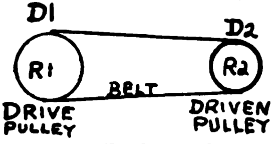
Drill Presses.

		Spindle Travel	Table Travel	Spindle Taper
Barnes Drill	Spindle to table, 26¾"	10"	16"	Morse No. 3.
Champion Drill	Spindle to table, 27"	..	16"	Morse No. 4.
Davis Drill	Spindle to table, 25"	9"	19"	Morse No. 3.
Canedy-Otto	Spindle to table, 25"	9"	17"	Morse No. 3

Address of mfgr's. of drill presses: Barnes Drill Co., Rockford, Ill.; W. P. Davis Mch. Co., Rochester, N. Y.; Champion Blower & Forge Co., Lancaster, Pa.; Canedy-Otto Mfg. Co., Chicago Heights, Ill. Grinders are manufactured by American Grinder Co., Milwaukee, Wiscn.

†Diameter and Revolution Formula.

This formula will explain how to find the size of pulleys to use—also see page 563.



$D1 \times R1 \div D2 = R2.$ $D2 \times R2 \div R1 = D1.$

$D1 \times R1 \div R2 = D2.$ $D2 \times R2 \div D1 = R1.$

D1 represents diameter of driver.

D2 represents diameter of driven.

R1 represents revolutions of driver.

R2 represents revolutions of driven.

---

*"How To Run a Lathe" and "First Year Lathe Work" are two 64 page pamphlets, fully illustrated—which will be supplied to readers of this book at 10c each. Address South Bend Lathe Works, South Bend, Ind., and mention that you are owner of this book. †See also page 563.

**See advertisement of South Bend Lathes in back of book.

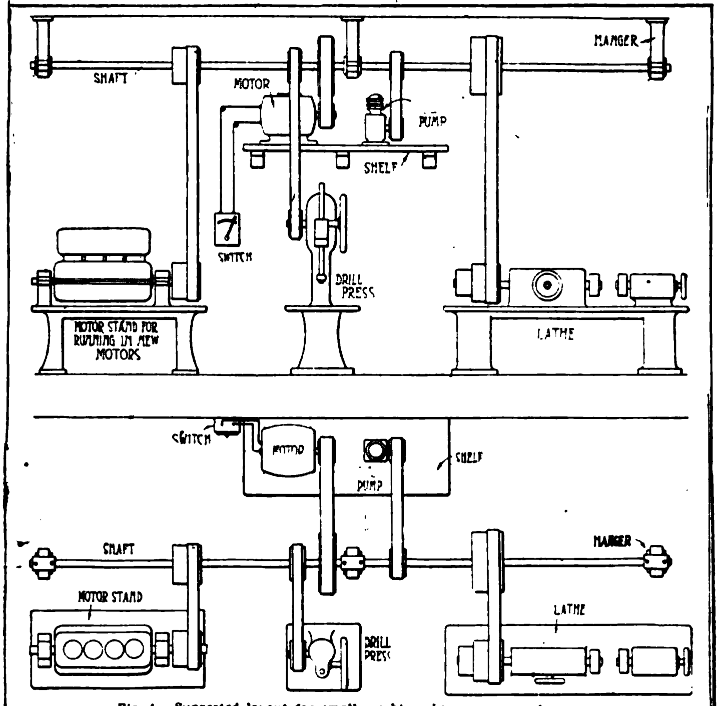


Fig. 4.—Suggested layout for small machine shop in corner of garage

Lay Out For a Small Machine Shop.

Fig. 4—Lay-out for small medium shop—driven by a 3 to 5 h.p. electric motor and with a motor stand for "running in" or "working in" engines after new rings are fitted, etc. The line shaft should revolve about 200 r.p.m. Line shaft is 15 to 20 ft. long with 3 hangers, 1½ or 1⁷⁄₁₆ inch di.

Fig. 5 shows another lay-out: In the illustration (exaggerated) we have laid out a standard line of machinery suitable for a machine shop. The line shaft is arranged in a straight line, whereas for close quarters it may be necessary to place two line shafts.

Although a gasoline engine and an electric motor for power are both illustrated, only one is necessary; both are shown in order to explain method for belting if one or the other is used. The electric motor is usually placed on the ceiling or on a post or shelf.

The gasoline engine ought to be equipped with a clutch in the drive pulley or in the pulley on the line shaft.

Approximate Pieces of Machinery Equipment.

1—20 inch drill press	$75.00 to 100.
1—16 in. x 6 ft. lathe	264.00
1—emery stand with 2. 6x1 wheels	20.00
1—sensitive drill press for small work	60.00
1—marvel No. 1, power hack saw	25.00
25'—line shafting and 4 drop hangers and belting	50.00
Compressed air outfit, belt driven from line shaft (see chart 237-B)	45.00

We will assume the electric motor is rented from the electric company. If not, add about $100 for electric motor or gasoline engine.

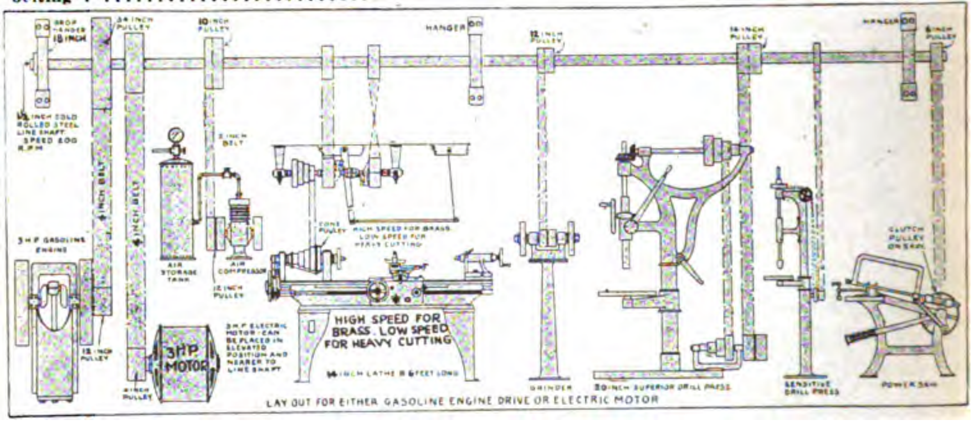
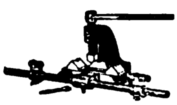
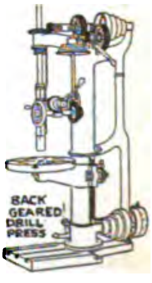

DROP HANGER 18 INCH
24 INCH PULLEY
10 INCH PULLEY
HANGER
12 INCH PULLEY
16 INCH PULLEY
HANGER
8 INCH PULLEY
1½ INCH COLD ROLLED STEEL LINE SHAFT SPEED 200 R.P.M.
3 INCH BELT
4 INCH BELT
4 INCH BELT
3 H.P. GASOLINE ENGINE
AIR STORAGE TANK
AIR COMPRESSOR
12 INCH PULLEY
CONE PULLEY
HIGH SPEED FOR BRASS LOW SPEED FOR HEAVY CUTTING
HIGH SPEED FOR BRASS. LOW SPEED FOR HEAVY CUTTING
12 INCH PULLEY
3HP MOTOR
3 H.P. ELECTRIC MOTOR CAN BE PLACED IN ELEVATED POSITION AND NEARER TO LINE SHAFT
8 INCH PULLEY
16 INCH LATHE 6 FEET LONG
CLUTCH PULLEY ON SAW
GRINDER
20 INCH SUPERIOR DRILL PRESS
SENSITIVE DRILL PRESS
POWER SAW
LAY OUT FOR EITHER GASOLINE ENGINE DRIVE OR ELECTRIC MOTOR

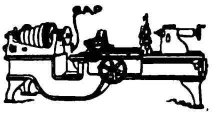
Fig. 5.



Shaft straightening press. While this press is made mainly for straightening shafts, it is also applicable for axle straightening as well. A tremendous power can be brought to bear, by the action of the long lever and heavy screw. A section of perfectly true shafting is centered between the adjustable tail stocks and used as a guide or measuring point as the shaft is being straightened.

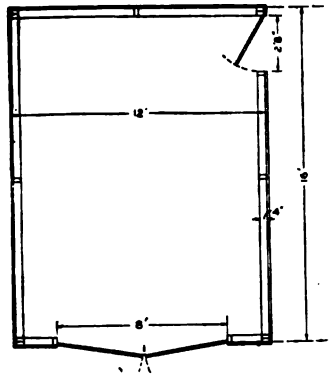


Back geared drill press. The advantage of the back gear feature, is obvious, as it is often very desirable to reverse the direction of rotation of a drill.

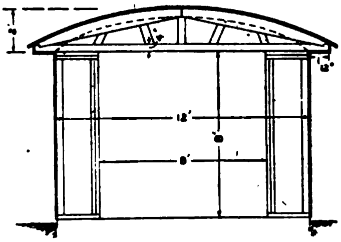


Gap-bed lathe. The distinguishing feature of this lathe is that the guides near the lathe head are cut away, thereby increasing considerably the size of the swing, without increasing the other dimensions. It is possible to handle much larger work with this style than could be handled on the regular type of the same dimensions.

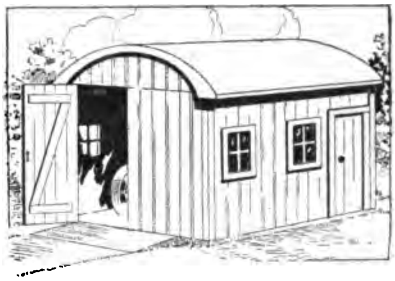
CHART NO. 248—Lay-Out and Equipment of a Machine Shop for Average Automobile Work—
("How to Run a Lathe"—see foot note bottom of page 617.)

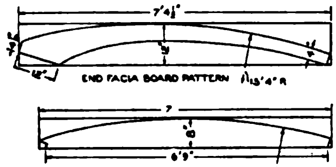


Floor Plan, Showing the Location of the Sills, Studs and Corner Posts on the Concrete Floor



End Elevation, Showing the Rafter Construction and the Finishing Facia Boards on the Eaves

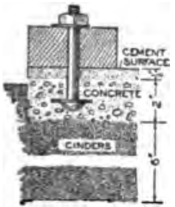




Pattern Layout for the Rafter Pieces and the Finishing Facia Boards for the Eaves at the Ends

The home garage shown in the illustration is designed for housing one machine, and to give a little space about it so that a person can clean the exterior of the automobile and do small repairs.

The first thing to be considered is the foundation, or base, which is made of concrete. The earth should be excavated for a depth of 6 inches and to the exact dimensions given for the floor plan. The hole is then filled with cinders, well tamped in and leveled on top. A frame, about 4 inches high, is built up of cheap lumber, so that the space within measures 12 ft. wide and 16 ft. long, except at the double-door opening where a sloping runway is formed for the easy entrance of the automobile. A 2 inch layer of concrete—a mixture of 1 part cement, 2 parts sand, and 4 parts gravel, or crushed stone is placed on top of the cinders, and a neat mixture of cement and sand, ½ inch thick is placed on the concrete and made perfectly level. When putting in the concrete, ½ inch bolts, about 5 inches long are set in the edge with the threaded end extended about 3 inches above the upper surface of the cement and in line with the center of the 2 by 4 inch timber used as a sill. The detail of this construction is shown in the sketch. About four of these bolts should be set on each side, three on the end, and one on each side of the double doors.



SILL CONSTRUCTION

The corner posts and studs are cut so that their length, together with the thickness of the sill and the two pieces for the plate, will measure 8 feet. This is the proper length to cut the boards without waste from standard lengths of lumber. After raising the corner posts and studs, and nailing the plate pieces on top, the siding boards are nailed on vertically to the plate and sill, and the battens nailed over the joints.

The rafters are built up in a manner similar to that used on large garages now so popular. Each one, or each pair, consists of a crosspiece that rests on top of the plates at the sides and is notched at the ends, to receive the ends of the convex rafter pieces. The pattern for one of these pieces, with dimensions, is shown in the drawing. After fitting the three main parts to form one rafter across the building, they are fastened together with short pieces of boards, which can be cut from scrap. The rafters are set on the plates 16 inches apart from center to center.

The sheathing boards are nailed to the curved edges of the rafters lengthwise, and as the material list calls for boards 12 feet long, one and one-half lengths will cover the rafters and allow 1 foot projection at each end for the eave. The facia boards are cut on a curve in the same manner as the rafter pieces, and the under side is cut as shown in the detail, so as to make a neat-appearing connection to the end of the frieze boards. Straight facia boards are fastened on the eaves, at the sides, in the same manner, and a frieze board nailed to the under side, the ends being finished, as shown in the detail drawing.

Prepared roofing is fastened to the sheathing in the usual manner, beginning the layers at the eave and finishing in the center, allowing the center piece to overlap on both sides.

The windows consist of four single casements, two being placed on each side. These can be of any size to suit the builder, and can be bought from a mill ready to be set into the openings cut for them.

The doors can be made up of the same material as that used for the siding and battened together, or, if a more elaborate door is desired, they can be purchased at a reasonable price, panelled and with a glass in the upper part. If paneled doors are used, 18 boards can be deducted from the siding-material list. The double doors will require fastenings at the center, and, in placing the concrete floor, a keeper should be set in the surface cement for the foot latch. The upper keeper can be attached to the end rafter crosspiece. The usual hardware is necessary for the small door at the opposite end.

A garage built up in this manner and well painted will last for years, and if it becomes necessary to move it, nothing will be lost except the concrete floor, as the building can be lifted from the bolts and taken away bodily.—(Popular Mechanics.)

Material List.

CONCRETE FLOORS:

2 bbls, cement.
4.5 cu. yd. cinders.
2.2 cu. yd. sand.
4.8 cu. yd. gravel

SILLS, PLATES AND STUDS:

6 pieces, 16 ft. long, 2 by 4 in.
4 pieces, 12 ft. long, 2 by 4 in.
20 pieces, 8 ft. long, 2 by 4 in.

SIDING:

90 boards, 8 ft. long, ⅞ by 8 in.
90 battens, 8 ft. long.

RAFTERS:

10 boards, 14 ft. long, ⅞ by 8 in.
10 boards, 14 ft. long, ⅞ by 4 in.

ROOFING:

Enough sheathing boards, 12 ft. long to cover 260 sq. ft.
Enough prepared roofing to cover 260 sq. ft.

WINDOWS...

4 single casements.

FINISHING PIECES:

2 frieze boards, 18 ft. long, ⅞ by 1 ft.
2 facia boards, 18 ft. long, ⅞ by 4 in.
4 facia boards, 8 ft. long, ⅞ by 1 ft.
8 corner boards, 8 ft. long, ⅞ by 4 in.
6 door facing boards, 8 ft. long, ⅞ by 4 in.

HARDWARE:

1 pair of door hinges.
1 door lock.
3 pair of heavy door hinges.
1 foot latch.
1 upper latch.
1 large door lock.
10 lb. 20-penny nails.
20 lb. 8-penny nails.
10 bolts, with double washers, ½ by 5 in.

CHART NO. 249—Building a Private Garage.

INSTRUCTION No. 46

REPAIRING AND ADJUSTING: Overhauling a Car. Cleaning and Lubricating. Removing Carbon. Causes of Loss of Power. Compression Tests. Refacing and Reseating Valves Adjusting and Timing of Valves. Bearings; constructions, adjustment and repairs. Pistons and Rings; fitting, testing, etc. Engine Knocks; how to locate and remedy. Reboring Cylinders.

What Constitutes a Car Overhaul.

Automobile overhauling is essentially a process of general cleaning, inspection, tightening-up and readjusting, involving, perhaps, some minor replacements, all of which will be explained further on in this instruction.

Engine.

Test compression; test for knocks, clean carbon, grind valves, adjust valve clearance, fit new rings if necessary, re-bore cylinders if necessary, take up on bearings; check the valve timing, examine valve springs, examine gaskets.

Ignition and wiring—test the ignition timing, test battery and electrical apparatus, clean spark plugs and adjust gaps, also clean, oil and adjust and tighten the generator and starter nuts etc., see that all ground connections are tight.

Clean engine: by flushing out old oil with kerosene as explained on page 201. Refill oil pan with a good grade of oil.

Miscellaneous engine parts; examine water pump, see if water hose requires replacement (see page 193); examine intake and exhaust manifolds and see that gaskets and joints are tight, (see page 192,) tighten all bolts and nuts.

Radiator.

The radiator should be disconnected and a stream of water forced through it for several hours. If scale exists, cleaning can be done with a solution of one pound ordinary washing soda and five gallons of water allowing to stand for an hour, (see page 191.)

Carburetion.

The carburetor should be removed and thoroughly cleaned and tested for float leak. Examine the gasoline line and see that all joints are tight.

Clutch and Transmissions.

The clutch is one part to receive attention, and here the repairman should resort to a large extent to the maker's instruction book if it is still at hand. The cone clutches are usually faced with leather or fabric. The leather can be cleaned with a dry cloth and then painted very lightly and evenly with neatsfoot oil. The fabric facing can be given a squirt-gunful of kerosene. Be free with oil on all the clutch connections and take especial care that the clutch thrust bearing is properly fed. Oil all connections from the clutch pedal lever to the clutch proper. Do not take up on the clutch spring unless you are certain it is needed.

With wet-plate clutches the housing should be flushed with kerosene and the engine turned over a number of times. At the same time the engine is turned over some one should push the clutch pedal in and out. This works the kerosene around the plates and tends to remove any gummy deposits. Then drain the housing, and repeat the operation. That finished, fill to the required level with oil. Usually 1 pint is used with one-half pint of kerosene.

With a dry-plate clutch the only thing that may be needed is a cleaning with kerosene, to remove gum. However, use a squirt gun in this case. No matter what the type of clutch be free with oil at all the various connections.

Look for small oil holes which are clogged with dirt. Oil the clutch cross shaft, the clutch collar and all the parts which move.

Universal joint:. Back of the clutch or transmission, there may be a universal. Clean it thoroughly with kerosene whether it is exposed or housed. Allow this to dry and then pack with graphite. If you have no graphite, get some or use a good grade of grease.

Next, proceed to the transmission. Drain the old lubricant, replace the drain plug, and remove the cover if there is one. Fill the case half full of kerosene and with a clean cloth mop it. This is a dirty job but it will be worth your while, because the gear-set usually is neglected throughout the year and is required to give efficient service with oil that is perhaps a year old. With the case clean add a grade of oil as recommended by the manufacturers, or see page 203. Don't put too much oil in the case. There usually is a level plug but if there is none, allow the level to be about up to the shaft of the highest or upper gears.

Running Gear Parts.

Wheels: First in order come the wheels. The car has been jacked up, and the next step is to see that the wheels run true on their bearings. There are many ways of doing this. A good way is to sight with one eye closed, while the wheel is revolving Any irregularity in wheel movement is easily detected. However, sometimes the rim is bent a little and one will imagine the wheel is running untrue. Grip the wheel firmly with both hands and test for side play and up-and-down play by pushing and pulling on the wheel in all directions.

A loose bearing usually causes this trouble and in many cases the looseness can be overcome by tightening the nut slightly. Some times new bearings are needed, because they are worn excessively.

Align the wheels as explained in charts 278 and 279.

The steering assembly, brakes and other parts require the same sort of attention and will be taken up in their separate order further on.

Rear axle should be cleaned and lubricated and the drive pinion tested as to it's relation with the drive gear on the differential. If noisy, it is probably loose and requires adjustment as will be explained under "Adjustment of rear axle gears."

Cleaning Engine.

We will take up the usual and common work required on all engines. We will first start with cleaning and lubricating the engine and greasing a car. About every nine cars out of ten require cleaning and greasing

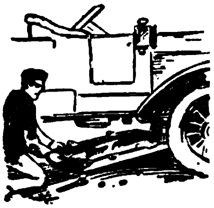


Fig. 1 — Remove drip pan and clean with gasoline or kerosene.

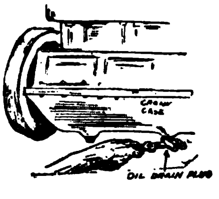


Fig. 2 — Remove drain plug at bottom of crank case to drain old oil.

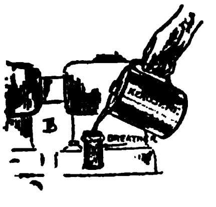


Fig. 3—Flush the crank case with kerosene. Pour through the place along side of engine where lubricating oil is poured in — called the "breather."

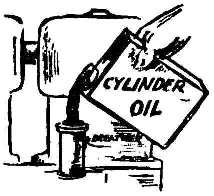


Fig. 4 — After crank case is cleaned and drain plug screwed in, put the best grade of cylinder oil in the crank case.

First start with the engine. Remove the drip pan, (fig. 1). Next unscrew the drain plug or open drain cock under the crank case. Drain all oil into a pan of some kind. This oil can then be placed in the oil filter, (fig. 2, chart 244) and used over again in the transmission, when mixed with grease or graphite.

It will be found that when oil stops dripping; if the starting crank is turned a few times by hand a little more oil will be found to flow. The best time to drain oil is after engine has been run and heated and oil is thinned. (Also see page 201.)

When the oil has ceased to come from the crank case the drain plug is replaced. It is not screwed tightly home as it is soon to be removed again. Now pour 2 quarts of kerosene into the breather pipe, (fig. 3) and run the engine again for about 15 seconds. If it is not in running condition open the compression cocks on the cylinder and spin it rapidly by hand. The longer this is done the better, but it is an arduous task and if kept up for a minute or so will be all that is necessary. The drain plug is now removed again and the kerosene is entirely drained out. The plug is screwed back and fresh oil provided.

Put fresh cylinder oil in crank case: In filling the crank case use only the very best cylinder oil, (see lubrication, pages 201 and 200). A gauge is usually provided to show how much to place in the crank case. If not, fill the crank case until it is about even with the center of crank pin when on bottom center. **Don't fail to place drip pan back** and tighten up all nuts.

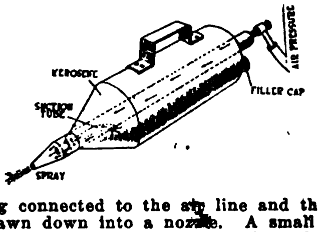
Note: Be sure all drain cocks are free by opening them and running a wire through.

The outside of engine and drip pan can be cleaned with gasoline. A brush dipped in gasoline to reach inaccessible places and also an oil gun to shoot gasoline* in inaccessible places will suffice. The lighting of a match or any kind of flame, however, while cleaning should be prohibited.

A modern method for cleaning the engine is by means of a sprayer. In large shops compressed air is used quite extensively for all kinds of cleaning.

Home Made Engine Cleaner.

A gasoline or kerosene spray, acting under air pressure, will quickly remove dirt and grease from the engine or chassis. A device for forming this spray is shown. It comprises a metal tank, holding the cleaning solution, and an aspirator for forming the spray. This aspirator is a copper pipe, passing through the center of the tank, one end being connected to the air line and the other being drawn down into a nozzle. A small copper tube connects this pipe, so that the solution is drawn from the tank and forced into a spray by the passing air—a foot pump can be used to inject air if pressure is not on hand. See also page 740. fig. 7, and page 744 for others.



---

*See Instruction 86—Cleaning and Washing a Car.

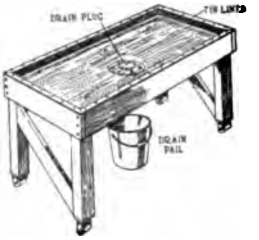
Clean The Exhaust System.

This cleaning should include the exhaust manifold, pipe and muffler. The latter should be taken apart and the parts soaked in kerosene over night. The pipe and manifold may be cleaned by drawing through a pack of kerosene-soaked waste attached to a long wire.

Keeping Oil Off the Radiator Hose.

To prevent oil from rotting the inlet hose from radiator to pump I have been giving the hose a coat of shellac and then a couple of layers of tape and shellac over that. The shellac keeps the oil away from the rubber.

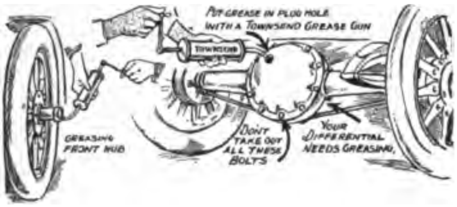
*Parts Washing Table.



This is large enough to permit any part of the car to be cleaned. But more important, it may be moved to the job. A wooden basin, or sink, 5 ft. long, 2 ft. wide and 6 in. deep is mounted on legs, and lined with tin. A drain plug is placed in the center, permitting the dirty cleaning solution to be drawn off into a pail hanging beneath the stand. Gasoline may be used for cleaning parts, but kerosene is cheaper and safer.

Greasing a Car.

One of the first things to do when starting to grease a car is to screw down on the grease cups, which forces out all grease therein, the cap is then unscrewed, grease cup refilled and cap placed back—but don't cross thread the caps or they will work loose and be lost.


PUT GREASE IN PLUG HOLE WITH A TOWNSEND GREASE GUN
TOWNSEND
GREASING FRONT HUB
DON'T TAKE OUT ALL THESE BOLTS
YOUR DIFFERENTIAL NEEDS GREASING.

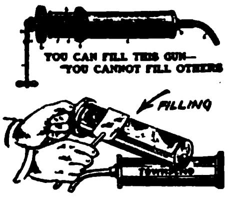
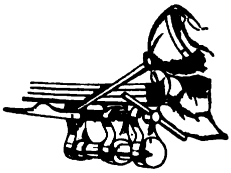


Fig. 2. The differential can be greased in the same manner as well as the wheels (if grease is required, see page 204 and 208.) This grease gun is thoroughly reliable and ought to be in every repair kit.

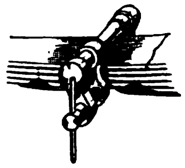
In greasing such places as the shaft of a cone type clutch (through a plug hole), the differential and other places on a car where a grease cup is not provided, but where grease plug holes are provided the Townsend grease gun is an excellent device. You can grease the differential gears, the universal, and every part of the car in a few minutes time, without removing the covers and all of those nuts and bolts.

Lubrication of Springs.

A detail which, if attended to, conduces much to easy running of a car, is the oiling of those parts of the springs upon which the leaves move. It is becoming the practice to make provision for proper lubrication at this point, which is easily done by drilling a hole through each leaf, as otherwise it is not easy when the weight of the car is on them to introduce any oil into the interstices. Very frequently, however, rust is seen along the joints, showing that water can get in, at any rate, and oil will work its way in, too, if applied at the edges,



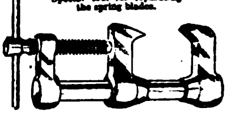
Lubricating the surface of the separated spring blades.



The same tool used as a temporary cramp to secure a broken spring.

but it will probably be found that this can be more easily done if the blades are separated by means of the special appliance illustrated herewith.

Rust in the springs affects their proper movement, and causes mysterious squeaks as well. The joints of the links connecting the upper and lower portions of the springs at each end should also have a little oil applied occasionally. It is when performing this duty that timely opportunity often occurs of observing defects of loose nuts or broken leaves in the springs. The nuts belonging to the clips which hold the spring on to the axle often display a tendency to work loose, and if this is not remedied the axle will be thrown out of line, with more or less serious consequences to tires and driving gear generally; or, if the front axle is in question, the steering may be affected.



Special tool for separating the spring blades.

If a car is overloaded much beyond its normal capacity, extra work will be thrown on the springs which may give rise to breakage when the car is being driven over bad roads. An extra leaf added to the springs is advisable for overloads. Considerable advantage to the life of the springs is obtained by having shock absorbers or buffer blocks fitted. (see spring covers, chart 236-E.)

Other parts of a car to lubricate and grease are shown on page 204.

---

*See also chart 306.

*Relation of Carbon to Lubricating Oil.

The oil film which protects the friction surfaces in your engine is hardly thicker than the page you are now reading.

It makes no difference how much oil you pour into your crank-case. The only oil **that protects your engine** is this thin film between the moving metal parts.

And this thin film **is not** the cool oil you pour into your crank-case. In use the oil heats quickly. Then the test comes.

Only oil of the highest quality will retain full lubricating efficiency under the heat of service.

Many oils break down under this heat. Part of the oil goes off in vapor, just as hot water gives off steam. With an oil film only .003 of an inch thick this vaporization must be reckoned with.

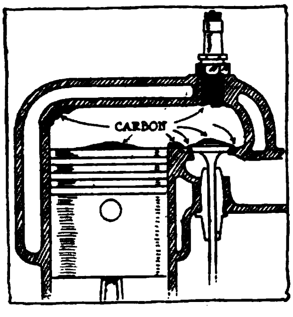
To get full protection, you **must have a constant**, full, even oil film. You **must** have an oil which will stand the heat of service.

The Cause of Carbon Deposit.

Due mostly to the use of poor grade of lubricating oil or too much oil, and quite often to an improper mixture of gas or too much gasoline being fed.

Carbon has many lodging places. It fouls spark plugs and kills the spark. It pits the valve seats and weakens compression. By accumulating on the piston heads and in the combustion chambers, it causes knocking and racks your engine with pre-ignition.

The amount of carbon deposited in your engine depends upon the carburetion and gasoline combustion and on the character of the gasoline as well as on the quality of the lubricating oil itself and the correctness of its body.



Showing points in cylinder where carbon deposits are most apt to gather.

As both gasoline and petroleum lubricating oils are chemical combinations of hydrogen and carbon, carbon is an essential element of each. See page 158.

Only the free (suspended) carbon can be taken out. To remove the carbon which is in combination with other chemical elements, constituting gasoline and oil would result in the destruction of the product itself.

Carbon deposit is likely to occur through incomplete combustion of the gasoline or through the destruction of the excess lubricating oil which will work into the combustion chamber if the oil is of incorrect body. "No carbon" oils do not exist.

To reduce carbon to a minimum, the lubricating oil must be of high quality and of correct body for the piston design and lubricating system of your engine. See page 200.

Lubricating oil adds materially to carbon deposit of an engine if the following conditions exist:

**1—Poorly fitting piston rings or scored piston rings and cylinders.

2—Carrying too high an oil level; using an oil that is not suited to the engine, both as regards body and quality, or carrying the pressure in a force-feed system at too high a point. See page 199.

†3—Allowing the oil in the crank-case or oiling system to deteriorate to the point that it is so thin that even a well-fitting piston ring will not prevent a surplus of oil from passing into the combustion chamber.

Relation of Carbon to Combustion.

An important consideration is the incomplete combustion of gasoline, for from this source a large proportion of carbon is deposited. When the charge of gasoline and air (the proportions of which are determined by the carburetor adjustment) is taken into the cylinder of a gas engine, it consists of hydrocarbon vapor and air. The oxygen in the air combines with the carbon and hydrogen of the gasoline and forms an explosive mixture. This mixture is fired, and after expansion the products of combustions are expelled from the cylinder through the exhaust valve.

If the amount of air entering the carburetor is not sufficient to insure complete combustion, we have what is known as a rich mixture. This is a slow-burning mixture rather than an explosive one and will cause excessive carbon deposit. **For example,** if the wick of an oil burning lamp is turned too high, too much oil will be drawn through the wick for the amount of air entering the lamp to form complete combustion. The lamp will smoke, and soot (which is carbon) will be deposited on the chimney.

This is exactly what happens in the cylinder of a gas engine. The products of incomplete combustion together with a portion of lubricating oil passing by the piston rings, deposit a certain amount of carbon in the combustion chamber. That portion of this carbon which does not pass out with the exhaust is baked on the cylinder heads, pistons and valves by the heat of explosion. This carbon deposit will build up very much more quickly if it has a bed to build up on, such as would be produced by a lubricating oil, which, when exposed to the heat of explosion, would leave a gummy deposit.

---

*Also see page 202.

**One cure for "scored" cylinders has been the judicious use of a special graphite lubricant. See page 205.

†See page 653, "piston pumping oil," and page 735 a "carbon remover."

Carbon Removal Methods.

Scraping.

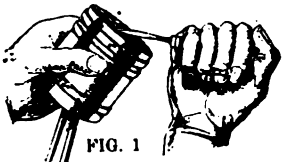


FIG. 1

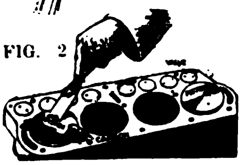


FIG. 2

Fig. 1 — Method: It is of course necessary to remove piston — usually from the bottom if small size piston—as explained on page 646.

Fig. 2—The cylinder head is removed and access is gained to tops of pistons and walls of cylinders. This of course applies to engines with detachable cylinder heads.

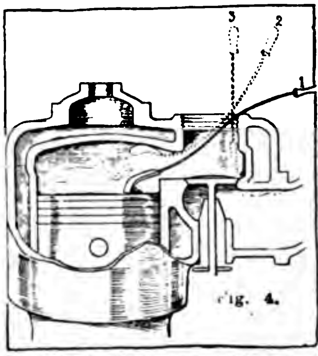


Fig. 4.

Fig. 4 — This method is employed when cylinder head is not detachable and with tools shown. The work can be done through the valve cap or plug holes on some engines.

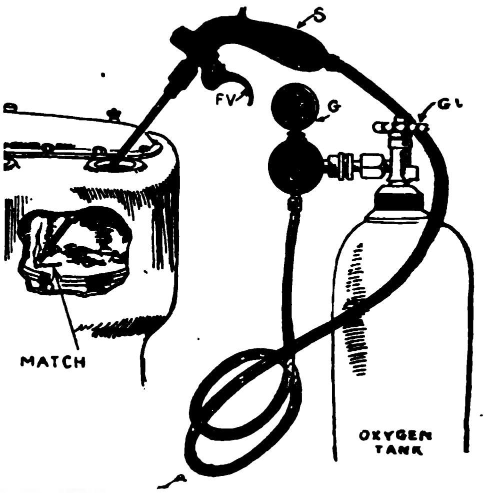
Special scraping tools are necessary: No. 1, is for scraping the piston head. No. 2, for the cylinder head, as shown by dotted lines and No. 3, is for the cavities over and around the valves and such other surfaces that have considerable curvature. Scraper No. 1, should be used first, and worked back and forth with considerable pressure across piston head until the scratching sensation disappears and tool seems to glide over the surface, care should be taken, not to gouge grooves in the metal. Blow out the free carbon now and then, (using a hand bellows), if compressed air is not available. Continue scraping until the blast of air does not blow out any more carbon dust and be sure to scrape the entire surface, for if jagged patches are left, they will become incandescent from the heat of explosion and cause pre-ignition.

It is important that none of the carbon gets into the cylinders, valves or other parts of the engine. Therefore be sure that valve is well seated in cylinder you are cleaning and it is also advisable to blow out the carbon with an air blast when finished.

Often after as much carbon as possible has been taken from the cylinders, a half-tumblerful of kerosene poured into each cylinder and the air blast applied, will give good results. Another half-tumblerful of kerosene should be poured into the cylinders and the engine turned over a few times.

The oil reservoir should then be drained and cleaned thoroughly with a clean cloth previously soaked in gasoline, and fresh oil put into oil pan (after cleaning and using kerosene,) as kerosene will thin the oil and cause it to lose its lubricating qualities and is liable to cause the bearings to score or cut, if any of the kerosene is left in engine combustion chamber to work into crankcase.

It is customary to grind the valves after having scraped carbon, and after grinding, adjust valve clearance.

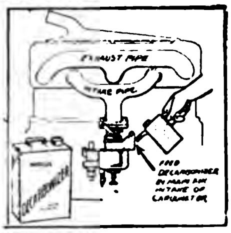


Oxygen Decarbonizing.

Fig. 6—Oxygen decarbonizing method: The valve cap on engine is removed and the piston brought to top firing position. A lighted match, wax taper, or small piece of burning waste is dropped into the cylinder. The operator then directs a jet of oxygen on the carbon with which the flame is in contact. This causes the carbon to burn fiercely and be entirely consumed. By following the burning carbon around the cylinder with the jet of oxygen, the carbon will be evenly burned out, see pages 726 and 727. This method will obviate the necessity of taking cylinders down and scraping and will greatly defer recourse to this rather expensive operation. The completeness of the results obtained depends somewhat upon the degree of accessibility to all parts of the combustion space which the particular cylinder design affords.

Routine of process: A tank of oxygen, at an initial pressure of about 1,800 pounds per square inch, fitted with an adjustable reducing valve that brings the pressure down to 10 to 20 pounds, is employed, and the oxygen is applied through a torch with a long,, rather fine, flexible delivery jet, communicating with the reducing valve through a flexible tube and fitted with a trigger valve (FV). The delivery jet of the torch when entered through a valve plug orifice, can be manipulated to reach all parts of the combustion space, if slightly bent and cleverly turned and twisted by the operater. (see Instruction 46C.)

The oxygen pressure necessary for successful carbon burning is about fifteen pounds. The working pressure should not exceed twenty pounds. The required pressure is secured by means of an oxygen reducing valve (see fig. 8, chart 293) with which the oxygen cylinder should be equipped before carbon burning is attempted.



EXHAUST PIPE
INTAKE PIPE
DECARBONIZER
FEED DECARBONIZER IN MAIN AIR INTAKE OF CARBURETOR

Fig. 5—Chemical method of cleaning carbon.

Chemically.

Fig. 5—There are several preparations on the market called decarbonizers; It comes in both liquid and powder form. This chemical dissolves the carbon and will also loosen the rings, see, explanation in text, page 628, under the heading "how a liquid decarbonizer is used."

CHART NO. 249-A—Cleaning Carbon—different methods—see chart 293 for oyx-acetylene welding For decarbonizing, only the oxygen tank is used.

Bad Effect of Carbon Deposit.

Carbon deposit will cause the **valves to leak** by the carbon gumming under the seat of the valve—thereby decreasing the power.

Carbon deposit cakes on the end of the piston and on the walls of the combustion chamber, which, when engine is hot will cause these small particles of carbon to become red hot and **cause premature ignition and result in pounding.** (see pages 233 and 635.)

Carbon deposit will also cause the spark plugs to become fouled, for if the oil you are using will cause carbon in one place it will accumulate on the spark plugs also. **In other words, carbon is a bad thing for an engine and ought to be removed.**

Soot or carbon deposit in an engine accumulates on the head of the piston and in the combustion chamber generally.

Indications of Carbon.

Carbonization of engine—general indications: If you should note that the engine, when fully supplied with water and oil and the spark lever in proper position, is overheating easily, has weak compression and developes a "knock" or "clank" when on a hard pull, there is probably a large deposit of carbon in the cylinder compression chambers. This may be due to the use of poor lubricating oil or incorrect adjustment of the carburetor. Even though it is not affected by these two conditions, a small residue of carbon will adhere to the interior of the compression chamber, and if left for a great length of time, will develop the trouble mentioned above. Of course the carbon sticking to the inside of a cylinder becomes red hot and **pre-ignites** the charge called **pre-ignition**—see pages 639 and 233. See page 202 for smoke indication of too much oil.

***Carbon Deposit Preventive.

Mix 85 per cent kerosene to 15 per cent denatured alcohol. Pour a few tablespoonfulls of this mixture into the cylinder of the engine through the relief cocks. To get the best results, the mixture should be poured in while the engine is still warm, after a run. Then close relief cocks, crank the engine with the switch off two or three times slowly; this will work the mixture thoroughly into the carbon. Then allow the engine to stand in this condition overnight. Next morning when starting there will be considerable smoke, but this will soon pass away. The exhaust "cut out" should be opened and the engine speeded up, so the dissolved carbon will pass out freely. This operation, if frequently used, will, to a considerable extent, keep the compression chambers and pistons clean. If there is considerable carbon already in cylinders before trying this, then it will be necessary to first have cylinders cleaned by scraping or by the oxygen decarbonizing process employed at some repair shop, because the carbon will probably be hard. After once cleaning the piston and by the use of this mixture and above all, the use of good oil, the cylinders should remain free from carbon. It is advisable to change old oil at this time, and put in a fresh supply.

Cleaning Carbon from Cylinders.

This is a job usually attended to when cylinders are re-ground. The frequency of the job depends upon the service, and quality and quantity of lubricating oil used. (see page 653.)

Methods of Cleaning.

There are five methods employed in cleaning carbon. The most effective being that one which removes the carbon most completely—probably by hand, but to remove piston is sometimes an expensive job and other recourses are resorted to as will be mentioned.

(1) One plan is to remove piston as per fig. 1, chart 249-A.
(2) To remove cylinder head as per fig. 2.
(3) To scrape with special scrapers as per fig. 4.
(4) To chemically clean and dissolve the carbon, see fig. 5.
(5) To clean by the oxygen decarbonizing process as per fig. 6, page 624. See also pages 726, 727.

This last mentioned method, is the most generally used and conceded to be one of the best.

No damage to cylinders: The piston of each cylinder to be treated is, of course, brought to its extreme head-end position before operations are commenced, this condition being indicated by both valves being closed and the fly wheel marking showing the engine to be on center, and thus no portion of the piston-traveled wall area of the cylinder is exposed to flame. In all water-cooled engines most of the combustion space is water jacketed, the mass of metal is large and the rise of temperature, even of the parts not directly in contact with water, is quite slow, so that the danger even of superficial oxidation is very slight as long as reasonable prudence is exercised. Iron will burn in an atmosphere of oxygen, but only when in very small masses so situated as to retard the dissipation of their heat, and when brought up to a very high temperature by the contact of some other burning material having a very high temperature of ignition. The laboratory experiment of burning an iron wire or watch spring in a bell glass of oxygen is familiar to all, but the wire must be very fine and tipped with a globule of burning sulphur or equivalent material before combustion can occur. The injurious burning of the extended surfaces of the relatively large masses of a cylinder head, while surrounded with water, seems out of the question.

***It is important that kerosene is not mixed with the lubricating oil as it will lose its lubricating qualities. Crank-case should be wiped out before putting in fresh oil, see pages 201 and 205.

***A carbon preventive called "Woodworth Carbon-Clear" mnf'g'd by Woodworth Mnfg. Corp'n., Niagara Falls, N. Y. is mixed with the gasoline; one spoonful to five gallons. It is claimed this will prevent the formation of carbon.

Note: In using oxygen for carbon removal. The piston should be placed at the extreme top of the cylinder, as the intense heat tends to roughen the cylinder walls. The flame should not be directed to strike the threads of the spark plug hole, and see that the water system is kept full of water. The torch should be moved constantly to cover as large an area as possible.

Questions Sometimes Asked.

Q.—Where can oxy-decarbonizing outfits be secured?

A.—The Prest-o-lite Co., Indianapolis, Ind., make a good cheap outfit, also the Turner Brass Works, Chicago; Imperial Brass Co., Chicago, and the Rice Co., Dayton, Ohio, see Instruction 46-C.

Q.—Can the Prest-o-lite tank be used for this purpose?

A.—The oxygen tank of their welding outfit can be used, but lighting gas cannot.

How Liquid Decarbonizer is Used.

In giving your engine the first dose (see fig. 5, page 624), and where carbon is well accumulated: start the engine and run until warm, shut engine down and pour the decarbonizer into each cylinder, say about ⅛ pint in each, where it can act on piston and rings. Also pour it over and around the valves. Leave the engine set over night, or at least three hours. After this time, start engine up and the carbon will pass off through exhaust. The compression and energy of engine will develop and you will be surprised at the power and results.

After once cleaning in above manner, about once every two weeks, feed the decarbonizer to the engine by placing about ½ pint in an ordinary oil can and let it pass in the air intake of carburetor while engine is running, it will suck into engine and will be sufficient, to keep rings and valves clear and to keep carbon from forming.

Why an Engine Loses Power.

Four main causes. When an engine fails to develop its usual power the cause is frequently one of the following. (1) loss of compression; (2) deranged valve action; (3) faulty ignition; (4) improper carburetion mixture.

(1) ***Loss of compression** means more than simply failure to compress the charge a specific amount; it is a common name for a condition which not only means low initial compression and consequent weak explosion, but also that a smaller charge is taken into the cylinder, that a portion of the diminished charge escapes during the compression stroke without doing even a small amount of work, and that a part of the explosive force (the only source of power that an engine has), escapes through unauthorized channels—altogether a threefold loss.

Faulty compression comes from a variety of causes; cylinders may be worn, scored or cracked, pistons sometimes crack, rings become gummed, worn or broken, valves need grinding when pitted or warped, their stems are sometimes bent so that the valves cannot seat perfectly, or the stems and guides considerably worn. Valve stems become gummed and the springs sometimes weaken, so that a portion of the charge escapes before the valve shuts it in.

Leaks occur around spark plugs and valve caps, but are readily found by applying a little oil, while engine is running and noting if it bubbles.

(2) **Valve action** is disturbed by wear, usually the valve tappets were not giving sufficient opening, or set to give too much opening, or valves not properly timed. Valves not seating of course comes under loss of compression.

(3) **Faulty ignition** is occasioned by insufficient or unsuitable sparks, or a spark at the wrong time (see pages 307 and 308), which may result from imperfect setting of spark, weak battery, either primary or storage, or from demagnetization or some other trouble peculiar to the magneto. The timer should come under suspicion and be carefully examined for defects which lead to irregular action. Lack of synchronism means loss of power, and it is plain that missed explosions are fatal to efficiency. It is not always easy to detect missing or weak explosions and no doubt they pass unnoticed many times. If vibrator coils are used they probably need adjusting, or their contacts need dressing, see page 234.

(4) See page 168 for carburetion mixture.

Other Causes of Loss of Power.

Air leaks around inlet valve stems, making it impossible for even the best carburetor and the most careful regulation to supply a right mixture, as the leakage fluctuates and is greatest at the very time when the volume of gas used is the smallest, because there is stronger suction when the throttle is nearly closed, thereby completely upsetting right proportions at all throttle openings except the one adjusted, also air leaks around carburetor or intake connections. (see page 162).

Weak valve springs will also cause loss of power as explained on page 635.

The muffler may have become clogged by soot and charred oil, thus preventing a free exhaust and consequently a full charge, besides causing back pressure and undue heating. **Gasoline passages may have become clogged.**

The oiling system may fail to supply the needed amount of oil, or the oil used may not be of the former good quality.

Carbon may have accumulated in the cylinders; air valve in carburetor may be working badly because of dirt or wear.

Dragging brakes will consume a lot of power.

Sometimes the addition of a top, etc., is not duly allowed for, though every driver must have observed what a difference the weight of one passenger makes.

In conclusion it is suggested that **if a car does not run with its former power the cause is probably not due to any one thing, but to a number,** each contributing in proportion to its importance.

***The explosion pressure runs from three to four times that of compression.** If the compression drops one-half, then the explosion pressure drops, but the loss is in more than direct proportion. It would seem that if the explosion pressure was one-half, the power developed would be one-half. But one must realize that it takes a certain amount of power merely to keep the engine moving. That is, to overcome the inertia and friction of the moving parts. This amount is constant. All power developed beyond this amount is available to run the car. If the compression and power drop to one-half, just as much power is required to run the engine, so that the available power drops in much greater degree.

*Compression.

The advantages of high compression are: greater engine efficiency at high speeds and greater economy in fuel. **The disadvantages,** are lack of flexibility at low speeds, greater strain on bearings and greater tendency to burn valves and plugs and also a tendency to over-heat.

A greater compression can be carried in an overhead valve engine regardless of stroke or bore, therefore larger valve openings are permissable.

Naturally this increases the heat, but as the valves are in the head, the discharge is rapid. The explosion pressure is generated directly above the piston center which receives no side thrusts.

The spark plugs in an "L" head type are usually over the inlet valves where the inrushing gas keeps them cool and where the fire is most certain—being in the most perfectly scavenged part of cylinder, i. e., the direct path of the fresh charge.

In the overhead type, on the contrary, they are exposed to the full heat of the explosion. In a high compression engine therefore only well-made plugs should be used. One method of protection is to surround the plug with a water jacket as much as possible.

Abnormal compression is prone to cause overheating. Results however can be obtained with high compression ratio, which cannot be approached with average compression.

If a high compression is desired in an L or T head engine, in order to take advantage of the high compression the cylinders must be designed with a sufficient long stroke, to enable the desired ratio to be obtained without raising the piston appreciably above the floor of the valve pockets, as at (L) in the illustration.

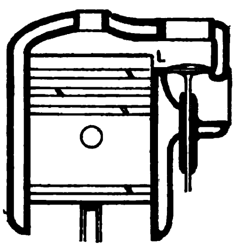


Fig. 1—This illustration shows type of piston referred to. It will be obvious that the explosion will develop in valve pocket (L) and part of its value lost when piston projects above top of cylinder to any great extent.

†Compression Average of Engines.

The most usual compression ratio for touring car engines, is about 70 or 80 lbs. per sq. inch. without the additional effects. This, when running at average road speeds, probably increases 90 to 100 lbs. or thereabouts. The Hudson is 110 lbs., Chalmers, 60 to 70 lbs.

A six, eight or twelve cylinder engine, having a much more continuous torque than a single cylinder engine, will obviously stand a higher ratio of compression.

The maximum compression is determined when throttle is wide open and all pet cocks closed. For instance the compression in cylinder of a Packard should show 75 to 85 lbs. pressure at cranking speed with pet cocks closed and wide open throttle.

Compression at time of explosion at instant when piston is at top of stroke is very hard to determine. Factors which would have to be taken into consideration are: character of fuel, degree of mixture, speed of engine. In the average engine, pressure at explosion would probably be about 250 pounds.

Compression Effect and Cause.

The subject of compression is one of the most important subjects connected with a gasoline engine—**if an engine lacks power, nine times out of ten it will be traced to poor compression.**

The compression space in an engine is the space between the end of the piston and the top of the inside of the cylinder at at (L), fig. 1. In drawing in a charge of gas into the cylinder, the piston travels downward, but after drawing in the gas through the intake valve, the valve closes and the piston on its up stroke pushes the gas up into the head of the cylinder and **compresses it.** (see page 307.) If the valve leaks, or there is a leak otherwise, then the gas will not be compressed to as high a pressure as if there was no leak.

These joints must be tight at all times. For instance, if the cylinder head gaskets or the small gasket in the spark plug, or the spark plug itself is not tight, gas will leak out and cause loss of compression and lack of power.

There may be a leak in the gasket connecting the intake pipe. This is a very common cause for missing at low speeds, and is best detected by allowing the engine to run at the missing speed (see page 162 and chart 292). Take a squirt can full of gasoline and squirt around all the intake pipe joints. If you detect any difference whatsoever in the running of the engine, there is a leak. The remedy is obvious.

**When cylinders are not cast en-bloc (see page 81) care must be taken that gaskets are of exactly the same thickness, otherwise the cylinder with the thickest gasket, will be raised higher than the others and consequently have larger combustion space and as a result have lower compression. This in turn disturbs the running balance.

In two-cycle engines conditions would be even worse, for here we not only increase combustion space, and enlarge the lower space (which in 2 cycle engines is an important feature,) but we also change the port timing, as a little thought on this subject will prove.

---

*See page 307 and foot note bottom of page 626 and index for "Compression."

**See page 640. †On engines using kerosene about 55 lbs. is the average. Note foot note about difference between compression and explosion pressure. Also see foot note page 909 and pages 793, 817, and foot note page 909.

Asbestos gaskets when replaced are first coated with shellac or soaked in linseed oil. Copper gaskets are soft and give, therefore do not require this treatment.

When the gas is compressed to the highest point, then the spark ignites the compressed gas and forces the piston down with great force. **If the compression pressure is low the force will be less. If the compression power is high the force will be greater.**

Leaks will affect the operation of the engine, in weakening the compression, diluting the fresh charge by the air that enters, the escape of the pressure during the power stroke, and the igniting of the mixture in the inlet pipe. **Therefore the power of an engine depends on good compression,** and good compression must be maintained.

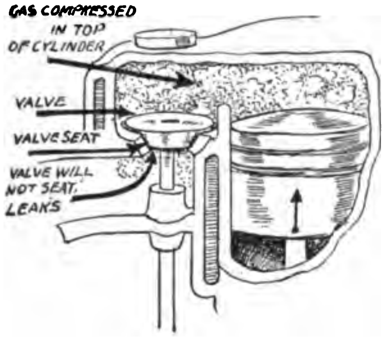


Fig. 2—If compression is poor, the probable cause; valves are leaking at the seat. (see also page 92.)

There are many places to look for compression leaks; through the valves not being set right or through the **valves leaking** at the seat, through the **valve caps** not being screwed down tight, through the **spark plugs, relief cocks and piston rings.** I have also known leaks to occur through a small sand hole in the end of the piston.

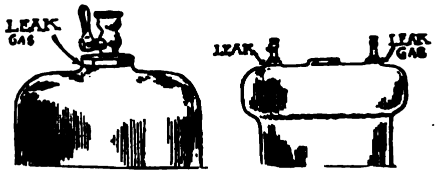


Fig. 3—Other causes of **leaks** may be in the spark plug, gasket or piston rings. (see also page 162.)

The most frequent cause of leakage is from pitted valves (see page 630), which by not closing tightly, permit the pressure to escape. If the valves are in good condition, and the spark plugs and other openings in the cylinder head are tight, leaky piston rings may be causing the loss and should be examined.

The spark plug and the relief cock may be made tight by the use of copper-asbestos washers, or by a copper washer, that metal being soft enough to be forced into the rough places, (see chart 292.)

Leaky valves may be ground in as described under "valve grinding." (see page 630.)

Other Causes of Loss of Compression.

It is probable that the cylinder wall, cylinder head, or piston head is cracked. A crack in the cylinder wall will admit water to the cylinder from the water jacket. If a hole is suspected, a test can be made on the cylinder to see if there is a leak by putting a foot pump connection to the water jacket of the cylinder, fill water jacket with water and apply the air pressure and see if bubbles of water ooze through, inside of cylinder. If this is the case then these holes must be made tight.

If water is found in the crank case, it is evident that there is a leak through cylinder from water jacket. It is possible, sometimes, to stop these leaks with salammoniac. See "index" for this subject.

To detect a crack in the piston head, it must first be scraped clean of the carbon deposit and examined carefully.

Sometimes there will be a discharge back into the carburetor; this indicates a leaky intake valve, providing it is not first found to be in the fault of carburetor adjustment.

Sometimes a discharge in the muffler indicates a leaky exhaust valve, but not always. It will require an experienced ear to detect the difference from that of an unfired charge being exploded in the muffler, due to carburetor adjustment and that of a leaky exhaust valve.

When the piston rings have been cut and scratched by long use, or running without oil, the leak will be into the crank case, and when this part heats so that it is uncomfortable to touch, it is an indication that it exists. The only remedy is the reboring of the cylinders, and the fitting of new piston rings, or if not too badly scratched new piston rings may suffice. Piston rings must be handled carefully, for they are very brittle. To place new ones in position, see chart 261 and page 657.

When piston rings are not pinned in position, they may work around in their grooves so that their split ends are in line, and this will often give the compression an opportunity to escape. Therefore, see that the split ends are not in line. (see chart 261.)

Piston Rings Cause of Leaks.

If the piston rings are in good condition, they will be smooth and shiny, as will also be the cylinders walls. If the rings are dull and dirty in spots and streaks, it will indicate that the flame passes between them and the walls, leaving a sooty deposit.

Badly fitting piston rings may be caused by the rings sticking in their grooves, because of gummy deposit from the lubricating oil; rings that are stuck in their grooves will not press against the cylinder walls and will cause loss of compression. Kerosene oil will cut this gum, and free the rings. If this is suspected, a little kerosene poured into the cylinder and distributed by cranking the engine will cure it.

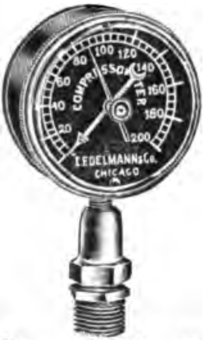
Leaky gaskets cause loss of compression: On page 717 and page 162, the different places for gaskets are shown.

**Testing Compression.

The compression is much easier to test than the carburetor or ignition apparatus.

***To test the compression of the engine** one has but to crank it slowly (with switch off) and note the comparative resistance of each cylinder and the resistance of all in general. If the resistance of the compression of one or more cylinders is comparatively poor, under ordinary conditions the valves of those cylinders need grinding. If the resistance of all of the cylinders is not up to the regular standard, then, perhaps, all require regrinding.

A method of testing with a special gauge is shown in fig. 4.



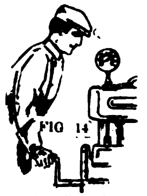


Fig. 4—Testing with a compressometer: This is a special gauge designed for testing the comparative pressure of each cylinder.

It is attached to the engine cylinder by removing a spark plug and fitting compresso-meter instead. The engine should be turned over two or three times either with the self-starter or crank.

Compression of the cylinder to which the compressometer is attached is indicated on the **instrument** as the **maximum hand** (short one) remains at the highest point so indicated. Note the two hands; the short one **remains** fixed at the highest point reached during the test.

As you test each cylinder separately, enter the reading on a slip of paper, then compare the results. Those cylinders showing low compression are leaking and the cause should be found and remedied.

A cylinder with good compression cranks with a springy resistance. If it cranks very freely, it may be considered an evidence of poor compression and the cylinders should be tested for compression one at a time, as follows:

The compression relief cocks (if a six cylinder) on five of the cylinders, say Nos. 2, 3, 4, 5, and 6, should be opened and the compression of No. 1 noted when turning the engine over. Then close relief cock No. 2, open cock No. 1 and crank again to test No. 2 and so on until the six cylinders are tested.

A leak through one or more valves generally is accompanied by misfiring and loss of power. A slight leak through all of the valves is accompanied by loss of power, but often without misfiring.

Grinding the valves will probably remedy this, if the leak is not due to leaky piston rings. Sometimes leaky piston ring trouble can be remedied by first giving the engine the kerosene treatment and tightening up the spark plugs and valve caps.

To test for a leak at the valve cap, spark plug, and relief cock: Pour oil over the cap on top of the cylinder block and if bubbles occur when the piston is moving upward, it is an indication that there is a leak. It can be corrected by simply tightening the cap or it may be necessary to renew gasket. Pour water into valve cap to detect leak where spark plug or relief cock is screwed into it. Leaks very seldom occur here, but when they do, remedy by merely tightening up.

A compression leak between the piston and cylinder walls is rather difficult to test—probably the best way, is to first correct valve compression leaks and valve cap leaks, then if the compression is still poor, then the leak must be between the piston and the cylinder wall. This can be corrected by taking out piston and putting in new rings.

The owner of a car, however, will very seldom be troubled by a compression leak between the piston and the cylinder wall as the rings are held in close contact to the cylinder walls by spring tension. This means that when free they are a little larger than the bore of the cylinder and they are sprung into place in the grooves of the piston and inserted into the cylinder, wear is taken up and contact surface perfected by the action of the spring tension.

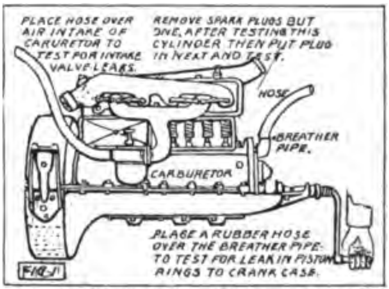

PLACE HOSE OVER AIR INTAKE OF CARURETOR TO TEST FOR INTAKE VALVE LEAKS.
REMOVE SPARK PLUGS BUT ONE, AFTER TESTING THIS CYLINDER THEN PUT PLUG IN NEXT AND TEST.
HOSE
BREATHER PIPE.
CARBURETOR
PLACE A RUBBER HOSE OVER THE BREATHER PIPE TO TEST FOR LEAK IN PISTON RINGS TO CRANK CASE.
FIG-5

Fig. 5—To test for intake valve and piston ring leaks—a suggestion.

To test for inlet valve leak: Place a hose over the carburetor air intake as per fig. 5. With throttle wide open, have some one crank engine with switch off. Place hose to ear; if a hissing sound is heard when piston is on compression stroke, the inlet valve is leaking and needs grinding.

Crank as before; if a hissing is heard, the pressure is escaping past the piston ring, down wall of cylinder into crank case. In this case new rings are required or maybe kerosene treatment will suffice.

---

*See page 627; "maximum compression determined with throttle wide open."

**If after these tests compression is not restored, the trouble is a serious one, requiring removal of cylinders. The piston rings may be broken, scored, or badly worn, or the cylinders may be scored also. Such troubles require a well-equipped repair shop, as new rings must be fitted and the cylinders reground. Keep in touch, so to speak, with the compression in your engine if you wish to obtain best results.

When spark plugs are constantly oily and fouling, this is an indication of oil passing from crank case past a loose ring.

It is also indicated by excessive lubricating oil smoke (blue) passing out exhaust, the oil works up past rings.

Spark Plugs Indicate Valve Condition.

The condition of spark plugs will sometimes indicate condition of valves. If the end of the spark plug is **oily** it indicates too much lubricating oil or leaky piston rings. **If black soft soot,** like that which accumulates in a lamp chimney, this indicates that too much gasoline is being fed to the cylinder through intake, causing too rich a mixture. This may come from improper carburetor adjustment or an air leak in intake manifold. If the end of the **plugs are oily and sooty,** this would indicate that the valves leak, as this permits burnt gases being drawn into the mixture, which would result in poor combustion and lack of pressure in cylinder, also permitting oil to pass and foul the plug.

Prussian Blue for a Valve Test.

To test valve head seat: Buy a ten cent tube of Prussian blue at any paint store. Loosen the valve spring, and **blue the face of the valve** and then turn it one quarter around in the valve seat. If the seat shows a clear clean line of blue, you have a perfect fitting valve. If there are points where the blue does not touch, you have worn or warped valve or a faulty seat.

To test valve seat: Reverse the operation and place the Prussian **blue on the valve seat,** repeating the one quarter turn. If there are points where the blue does not touch, the valve and seat both require attention.

Valve Troubles.

To determine if valves need grinding or reseating: Valve grinding will ordinarily remove small pits, but if badly pitted or if valve head is warped (caused by excessive heating), out of line with its seat, or if shoulders appear on the valve face or valve seat, they should first be re-seated with a special re-seating tool and then ground to a smooth surface.

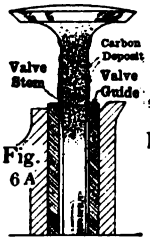


Fig. 6A

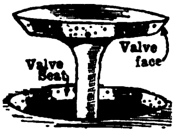


Fig.6

Fig. 6—Note the black spots on valve face and valve seat. This permits the escape of gas. If ground or reseated the spots will be removed and valve will seat tight, if pitting is not too deep and valve spring not too weak.

Fig. 6A—Exhaust valve stems often become carbon coated and when engine is driven at high speeds the temperature increases, causing expansion, and the result is the valve will be given a taper effect which will not permit valve to seat properly. Often times this is the cause of a **leaky** valve and stem should be cleaned thoroughly and sufficient clearance allowed between valve **stem** and valve guide.

Refitting New Valves.

When valve stems become badly worn, it is almost a certainty that the guide or hole through which the stem passes is also worn out of round. The cheapest and best way to remedy this, is to ream out the guide hole and install another valve with an "oversize" stem, as shown in fig. 21.

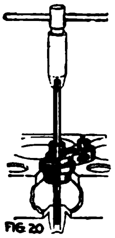


Fig. 20 — Guide reamer for reaming oversize valve guide.

Fig. 21 — Valve with oversize stem.

The reamer set (fig. 20), includes a **case** hardened guide, which fits in the valve cap recess and insures that the finished hole will be true and in perfect alignment.

The over-size valve stems vary in size by 64ths of an inch and usually 1-64 larger is all that will be found necessary, unless too badly worn, (see page 609.)

Grinding Valves.

Valve grinding is necessary when either the inlet or exhaust valves leak. The exhaust valve has a tendency to leak more than an inlet valve because it is more exposed to the heat.

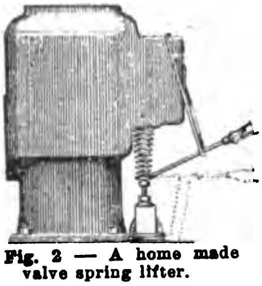


Fig. 2 — A home made valve spring lifter.

To test if valves need grinding, see above "Prussian blue test." Also try the compression. Weak compression usually results from leaky valves also leaky rings, therefore be sure it is the valve and not the rings.

***To grind valves is not a difficult process.** It is merely a slow and pains taking job, and is better done the more patient and untiring the operator is. Don't let any one tell you that it requires an expert or a mechanic, as such is not the case.

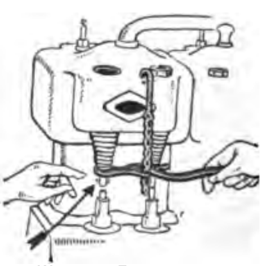
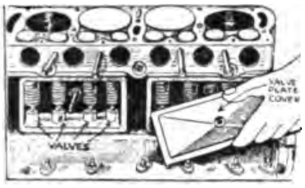


Fig. 1—Remove pin in end of valve stem. A spring lifter will make this easy.

First remove the intake pipe (if it is in the way). Remove the valve cap. Use some

*If the repairman finds difficulty in grinding some of the valves, owing to the fact that the abrasive will cut the surface very slowly, it is because that particular engine has a very hard alloy steel Tungsten valve. When fitting new valves call for Tungsten metal valves. However, good valves are also made with cast iron heads welded to steel stems.

form of spring holder so that the tension of the spring is relieved while the key is taken out from under the spring. These springs are very stiff and will require a special spring lifter of some form which can be secured at any supply house or you can make a serviceable tool, of a ½ inch iron bar, about 18 inches long and split at one end, as per fig. 2, (page 630.) **After the key is removed, then the valve is lifted out** of its seat. (see also page 92).



Valve cover removed exposing the valve springs.

Second, place some valve grinding compound on the face of the valve. The usual proceedure is to first apply a coat of oil on the seat, then distribute it with the tip of the finger; then dip the finger into the emery (flour of emery) and apply this to the seat. Put on an even coat and don't plaster it all around the surrounding metal parts. Take your time.

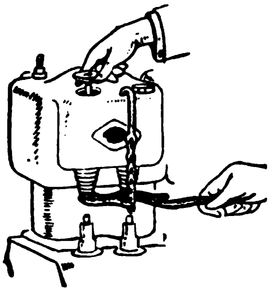


Fig. 3—Lift valve out of cylinder.

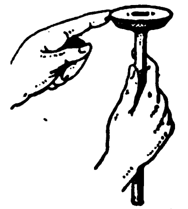
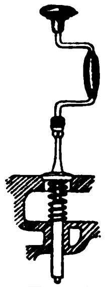


Fig. 4 — Smear the valve grinding compound around edge of valve.

There are special prepared grinding compounds which can be secured at supply houses. It comes in three grades No. 1, No. 2, and No. 3. The first is coarse and cuts heavily; the second does not cut so much, and the third polishes.

Third, place valve back into seat; then use a screwdriver or a brace with a screwdriver bit, placing the point in the recess, with which most valves are provided.



There are various ways to grind valves; with a breast drill or brace and screw driver bit or by hand. with a regular screw driver, or by machinery, see also pages 632, 633, 616, 615 and 592. There are numerous valve grinding tools on the market.

A spring should be placed under valve as shown. This will allow the valve to raise from its seat occasionally. Place a cloth in the opening to cylinder to prevent the grinding powder and dirt getting in. And be sure and take it out when through.

Fourth, turn the valve half a revolution back and forth in its seat, and occasionally lift from its seat and shift around. Don't turn round and round.

When the pits on the valve are almost removed, continue the operation with flour of emery of a finer grade instead of the coarse grade; remove the valve oftener, applying more oil and less emery each time, until a good seat is obtained all around; then finish up by polishing the seats with oil. Kerosene is most effectively used in finishing, and the smoother the finish obtained the less chance for a leak. Be sure valve stems are free in the guides.

Remove valve and clean both head and seat with kerosene and don't overlook cleaning the valve stem.

If a polished seat is desired, finish as follows: When the valve is ground to a dull, smooth surface, remove and clean valve face thoroughly. Do not clean valve seat, but leave upon it the compound which remains from the last grinding. Replace valve and give twenty or thirty turns. Remove again, clean valve, but not seat as before. Replace valve and repeat until the desired polish is obtained. The polished seat may look somewhat better, but the dull smooth seat gives much better results, as has been proven by test.

When grinding valves, a pressure of about 3½ lbs. is sufficient. More pressure than this will cause grinding compound to cut rings in the valve or seat.

A valve that is properly seated will bounce back when dropped into its seat. If it stops with a dull thud, either the grinding is not perfect or the valve stem is bent.

After grinding valves adjust the valve clearance as per pages 94 and 634. It is advisable however, to allow the valve tappets to run loose for a period of several days before adjusting them to the minimum amount of clearance or space.

*Grinding Cage Type Valves.

The above instructions are for grinding the poppet type of valve in an "L" or "T" type of cylinder. If the valve is of the, "cage" type, used in some of the I head cylinders, then the cage must be removed as shown in illustration, fig. 2, chart 250. The cage is placed in a countersunk hole in the bench, with a spring under the valve to raise it. In fact it is a good idea to place springs under all types of valves when grinding as shown at top of this page—right hand illustration.

If the spring is tied as shown in fig. 3, chart 250, it will be easier to replace.

To tell when valve is ground or has a perfect seat, see page 630; "Prussian blue test." Another method is to mark the valve face with a pencil, as shown in fig. 3, chart 250.

Reseating Valves

Is explained in chart 250. Ordinarily valve grinding will answer, but if valves are badly pitted, warped or a shoulder appears, then it needs refacing and reseating.

Q.—I have a Mitchell 6-50-1914 model. Valve seats have been ground till the valves drop a ¼ inch into seat and the valve is not level with the combustion chamber till the piston has descended ½ of suction stroke. Valves are 2¼ ins. Cylinder bore 4¼, stroke 6 ins. Would it do to reseat with a 2½ inch reseater and use 2½ inch valves?

A.—Your suggestion to use 2½ inch valves is a good one. Leave the seat narrow so it will last longer. 1-16 to ⅛ inch is wide enough for the seat in the cylinder. You can get the valve blanks at the St. Louis Machinist Supply Company, St. Louis, Mo., or most any auto supply house.

---

*To grind overhead type valves with valve seat in cylinder head, see page 636. To grind overhead type valves where they are operated by overhead cam-shaft, see page 913.

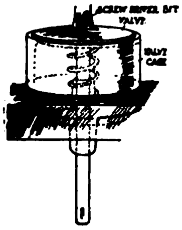


Fig. 2.—Cage type of valve. To grind this type, remove cage and valve and grind in same manner as the poppet valve, see fig. 3, page 90, fig. 4, page 94.

Overhead operated valves on an engine not equipped with removable heads are of the cage type (see pages 90 and 91). They are also of the "valve in head" type, see pages 90 and 109.

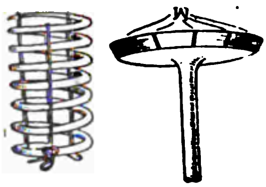


Fig. 3.—To test the finish of a valve face after grinding: mark it with a lead pencil as shown about ½ in. apart or less; after putting valve in place and oscillated about ¼ turn, if all marks are erased the job is satisfactory. (The marks on valve "W" are the pencil marks to be erased.) The Prussian blue test, is also a good method for testing, see page 630.

Tie the valve spring before trying to replace it. A simple method is to compress a valve spring between the jaws of a vise. Whilst compressed it is tied up with a loop of wire or string in two or three places. When the spring is thus tied up under tension its replacement is easy. This is not necessary if a valve spring lifter is at hand, see page 630.

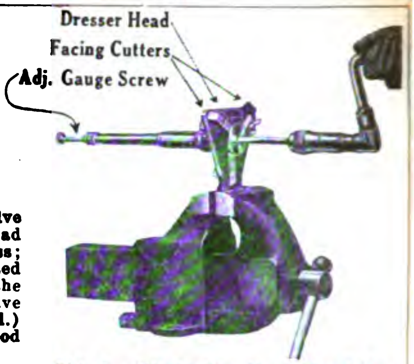


Fig. 5.—Illustrating the method for **refacing** a valve with a Healy refacing tool.

Refacing Valve.

The subject of valve grinding is treated on page 630. Where valves are badly pitted or warped, or where shoulders appear, this will then require more than mere grinding. A special tool is therefore required to reface the valve and for reseating the valve seat.

The dresser head for refacing the valve and a reseater for reaming out the valve seats—both being adjustable for different size valves, is shown in figs. 5 and 6.

Refacing a valve is shown in fig. 5. This method was the approved method when valve stems were made of steel and had a cast iron valve head electrically welded to stem, but now, many manufacturers are using hard tungsten steel valves, therefore the usual way a tungsten valve is refaced is by putting it in a lathe and emerying it down.

The McCullough valve refacer however, will save the necessity of doing the work in the lathe and will accurately reface any valve, tungsten or other kinds of metal valves in one or two minutes time, see fig. 7.

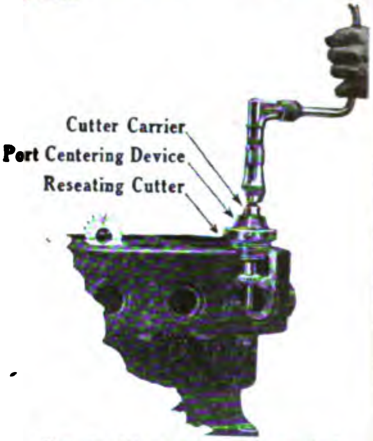


Fig. 6—Illustrating the method of truing up a valve seat and reaming a worn valve stem guide. (Healy Tool & Ap. Co., Buffalo, New York.)

Reseating Valve Seats.

Truing up a valve seat in the cylinder is usually done with standard sizes of valve reseating cutter, one type is shown in fig. 6.

When reseating valve seats the novice must be careful to not cut too deep into the seat and thereby lower the valve stem. In fact, it is advisable to **adjust the valve clearance after either grinding or reseating valves.** After reseating, always grind the valve in order to make a good tight seating. (see fig. 8, of an improved method of reseating valves.)

A perfect seat is assured when a white line extends clear around both the valve and the seat, when giving the prussian blue test. The width of the line is immaterial, but the narrower the line, the better the compression will be because there is less area for the pressure of the valve spring to act on. However, it is not well to have the ring less than ⅛ inch wide.

A valve seat should have a bevel of not less than 45 degrees. Less than this the valve will stick. A good angle is 60 degrees.

It will be noticed that some valve stems seem to wear very much on one side. This may be caused by one or more of three things, viz: the hole is not concentric with the valve seat — which can be remedied by reseating in a radial drill press; the top of the valve lifter is not at right angles with the valve stem, wedging it off to one side, or the same may be true of the valve cap on the stem of the valve. These two latter troubles can be remedied by the judicious use of the file.

Reaming Guides.

Worn valve stem guides allow air to be drawn through, which causes an imperfect mixture. In this instance the valve stem guide ought to be reamed out and an over size valve put into its place, (see fig. 21, pages 630 and 609.)

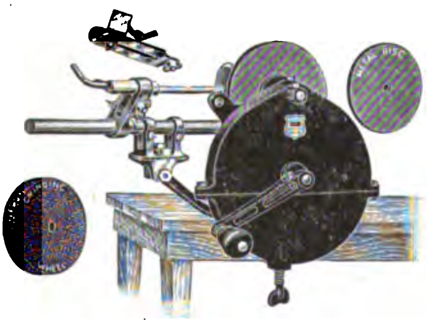


Fig. 7.—The McCullough valve refacer. Will reface hard tungsten valves and other kinds. Cutting surface is carborundum cloth, glued to steel discs, an emery wheel is furnished with the outfit, also a valve reseating tool as shown in fig. 8, (write B. L. Fry Mfg. Co., St. Louis Mo. for descriptive folder).

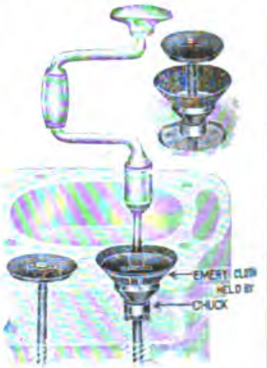
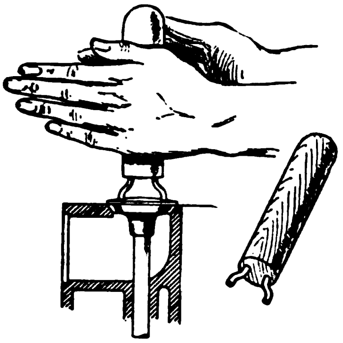


Fig. 8.—McCullough valve reseating tool consists of a carborundum cloth cone held to the face of the valve as shown. The valve is used just the same as a reamer The cloth cutting the seat in the cylinder exactly the same bevel as that of the valve face. No reamers are required. There is nothing to replace but the carborundum cloth. Emery cloth or sand paper will do quite as well but will not last as long.

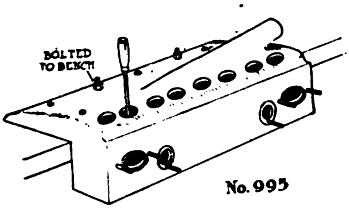
100 or more valves can be refaced with one cloth disc, fig. 7. and 10 or 12 valves can be refaced with one cloth cone. Mfg'd by B. L. Fry Mfg. Co., St. Louis, Mo.

CHART NO. 250—Refacing Valve Heads, Reseating Valve Seats and Reaming Valve Stem Guides



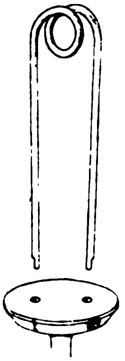
EMERGENCY VALVE TOOL

An emergency tool for grinding Ford valves may be made from an 8 in. length of broom handle and two nails. The two nails are driven into the sawed off end of the handle, until only about one inch of the nail is left. The heads of the nails are then filed off and bent until they will fit into the drilled holes in the valve top.—



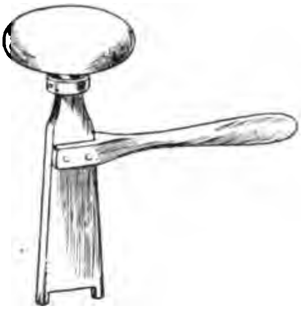
MAXWELL VALVE GRINDING

The cylinder head of the 1914 and 1915 Maxwell should not be removed unless absolutely necessary, but when removed valve grinding is facilitated by bolting the head to the bench in the manner shown. Not only are the valves more accessible, but the light at the bench is usually better than at the repair stand.—



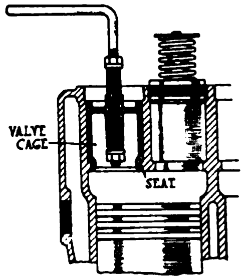
VALVE LIFTER

Valves designed to be ground by means of a spanner wrench may be lifted from their seats by means of a valve lifter made from a spring steel rod. A piece of 3/16-in. round rod, about 14 in. long, is heated and bent in the form illustrated, after which the coil is spring tempered. The points are filed down until they are a snug fit in the holes in the valve top. Valves may be ground and readily lifted out for inspection by means of this device.—



VALVE-GRINDING TOOL

A simple tool for facilitating valve grinding is illustrated. The body of the tool is made of 1¼-in. flat stock, 3/16 in. thick and about 6 in. long. The upper end is forged round and fitted with bit-stock hand rest, the lower end carrying the jaws for engaging the valve. A short length of round stock riveted on provides a convenient handle. A similar tool with a screwdriver point may be made for valves with a slotted head.—



GRINDING BUICK VALVES

A simple way of grinding a Buick valve cage to a perfect seat is shown herewith. Through the center of the cage insert a round iron rod which has been threaded for a nut at the two places shown. Then tighten the nuts. With the rod as a handle, the cage can be rotated easily.—

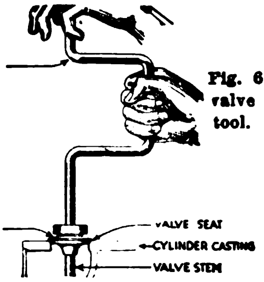
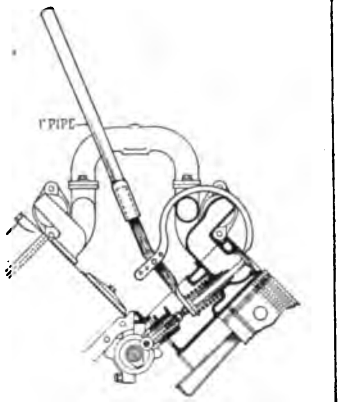


Fig. 60—Ford valve grinding tool.



COLE 8-VALVE TOOL

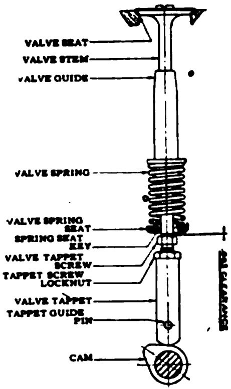


Fig. 20—A valve and its parts. Ford valve has no tappet adjustment.

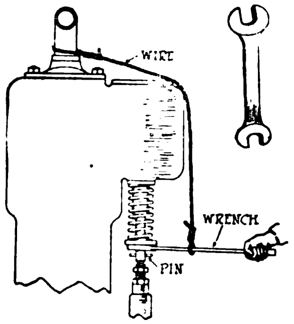


Fig. 27—Another method of releasing spring tension to remove pin or washer on end of valve with use of a flat wrench.

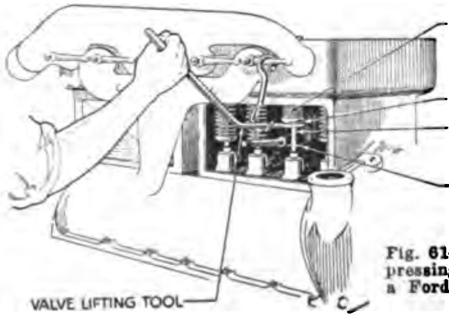


Fig. 61—Method of compressing valve spring on a Ford.

CHART NO. 250-A—Handy Devices for Valve-Grinding.
(Motor World.)

Noisy Valves—figs. 2 and 3.

Difficulty is frequently experienced in locating noises in and about the engine, probably because there are so many of them that it is difficult to determine where to begin.

Attention to the valve-stem clearance usually becomes necessary when the valve becomes lowered as the result of repeated grindings.

The best way, perhaps, is to go about it in a systematic manner, starting with the most likely sources, as in the valve lifts.

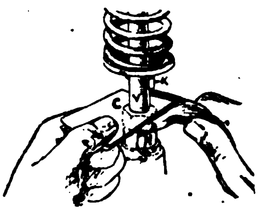


Fig. 1—Valve Adjusting.

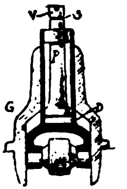


Fig. 2—V—valve S—space between valve and plunger. P—plunger

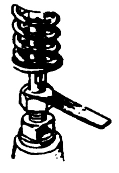


Fig. 3—Tool inserted between valve and plunger to find if the noise ceases

Referring to the accompanying figure; place a thin piece of metal under a suspected valve stem, as shown in fig. 3, and when the noisy one is found the insertion of the tool will cause the clicking to cease abruptly and will remain quiet until tool is removed.

The repairman can generally find a tappet that is badly out of adjustment in a very short time by simply working the tappets of each cylinder up against the valve stems and down again, with his fingers, while the pistons of the respective cylinders are on their compression strokes.

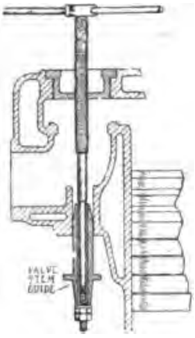
Proper adjustment of the valve tappets will help in reducing the noise which invariably occurs when there is any wear.

***The proper space between the ends of the push rods and valve stems** is as explained in charts 44 and 228 and pages 95 and 110. The smaller the space, the less noise; but sufficient space must be allowed due to expansion when the engine is warm and irregularities in shape of cam or roller.

Sometimes one or two tappets may need adjustment, while others may be in good shape; in such cases there will be a clicking sound at regular intervals.

Valve Adjusting—fig. 1.

In the absence of a suitable gauge for regulating valve space, many repairmen use a piece of paper as shown at (O) fig. 1. It is folded once and slipped between the ends of the stem and tappet, the lock nut N is loosened, and the stud S in screwed up or outward until it just begins to pinch the paper and prevents it from sliding about as readily as at first. The paper is then removed and the lock nut is tightened.



When both the inlet and exhaust valves have been adjusted in this manner, each one should be individually tested with a single thickness (a thickness gauge is best—see chart 284, also see chart 228 for the adjustment or gap necessary for leading engines) to see if the valves remain tightly closed throughout their required period. This is best done by sliding the single thickness of paper back and forth as the engine is being turned slowly from the closing to the opening points of each valve. The marks on the fly wheel may be used to advantage in this operation if accessible, but they are not necessary. One can slide the paper under a stem and turn the engine over until the paper is seized, indicating valve opening, then a little farther until it is free again, which marks the closing of the valve; now, by turning still farther and continually sliding the paper about, if it is not seized before the regular time for the valve to open (according to either the position of the piston or crank handle), the adjustment is about right, but if the paper is prematurely seized the space is insufficient. The valve in each cylinder should be adjusted in the same manner.*

Valve Guides.

Fig. 7—Replacing valve guides: The valve guides of T- or L-head motors may be driven from the cylinder casting from above. The fitting of new guides must be done with more care, however, as a slight distortion of the guide will cause the valve to stick. The puller illustrated is ideal for this work, as it applies a steady, even pull to the guide in a manner that cannot spring it out of shape. An old cylinder cap is drilled and tapped to carry the threaded rod, which may be made on the lathe in a few minutes.

Many valve guides are not bushed but are simply drilled passages in metal of engine, as per fig 7, page 94.

In this construction, the guide is reamed larger and an oversize valve put in as per pages 680 and 609. Where separate bushings are used as in the illustration above, the old guide is driven out from the top and a new bushing drawn in from bottom as shown.

On older model (Dodge cars) the valve guide was integral with cylinder and a 35/64" drill bores out worn guide. Then a .556" reamer is run through. Then a finishing cut taken with a 9/16" reamer. **Average clearance** is .002 to .008.

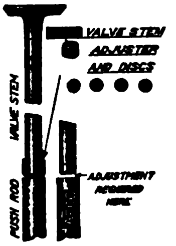


Fig. 9.

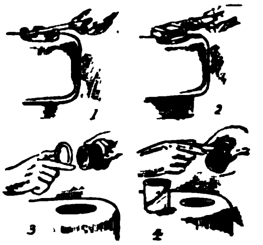


Fig. 10.

Fig. 9—Valve adjusters: where no provision is made for adjusting the valve clearance, adjusters made of steel lined with fibre (to reduce noise) can be had of supply houses.

Fig. 10—Valve caps—are placed over each valve and are finely threaded and provided with copper gasket (8). The threads should be coated with graphite when removed—else one will have difficulty in removing. (1) shows a castellated type which sometimes is sunk into head of cylinder and requires a special tool to remove.

CHART NO. 251—Adjusting Valve Clearance. Replacing Valve Guides. Removing Valve Caps—also see pages 95 and 110; charts 228 and 284.

***On some engines the exhaust valve is given slightly more clearance than the inlet valve.** For instance the Pierce-Arrow gives .008 for inlet and .004 in. space for exhaust—also on the **Dodge.**

Adjusting Valves and Tappets.

The result of improper valve clearance will cause lack of power as explained on pages 94 to 99. Noise will result as stated in chart 251.

To find which valve is noisy (clicking noise) fully explained in chart 251 and 254, another method is shown in fig. 2.

To test: Let the engine run so that the noise is heard and then grip each valve spring firmly and pull it up with the hand against spring tension, as shown, so that the valve is not active. This is equivalent to running the engine with seven valves (if a four cylinder engine). Each valve should be lifted in this way and when the noise ceases, the noisy valve is the one which is being held. (also see chart 254).

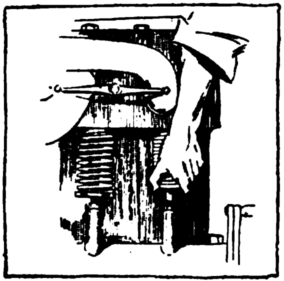


Fig. 2 — Holding up valve with engine running.

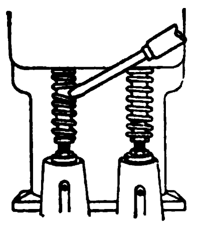
When adjusting valve clearance, remember that if no space at all is left between the valve and plunger, then the valve will not seat properly; therefore, it is important to get the distance exact.

Valve Springs.

If the springs of the exhaust valves become weak from use or heat, the pistons will draw burnt gases into the cylinders, past the valves with the incoming gasoline charge, giving an improper mixture. The valve springs should be tested occasionally to see if they are full strength. The averare strength of a valve spring should be thirty pounds. At high engine speed exhaust valves nearly always permit some leakage, but at high engine speed this is an advantage. (see page 742, fig. 2.)

Valve springs that are too stiff are to be avoided because they may close the valves with so much force as to break the stems at the key, or the heads from the stems, and it is a certainty that the seats will be pounded out of shape, even if the valves do manage to stand the constant hammering action. An **excessively** stiff spring consumes power which might be used to a better advantage and there also is considerable noise.

To increase the tension; stretch the spring **a mere trifle** by slightly opening up the coils with a screwdriver or by securing one end coil of the spring in a vise and tying a cord or the like onto the other end so as to get a grip, and then stretching it a little in the ordinary way.



Another way to increase the tension is to place a couple of washers under the lower end of the spring.

To test for a weak exhaust spring, insert a screw driver between the coils, thereby increasing the tension. If missing stops then remove spring and stretch it about an inch or put in a new one.

The reason of missing of explosion from a weak exhaust spring is, that when the throttle is closed, the piston cannot get much charge, and consequently it sucks the exhaust valve open and draws back some of the burned gases, which spoils the small charge in the cylinder, thereby causing it to miss fire.

A weak inlet valve spring also makes itself evident by the mixture back-firing into the carburetor. Springs too weak to hold the valves on the cams will also produce clattering noises owing to belated seating of the valves.*

**Knocks.

Knocks are usually caused by the following parts being loose or worn:—

(1) Lower connecting rod bearings;
(2) Upper connecting rod bearing or wrist pin;
(3) Main crank shaft bearings;
(4) A loose piston;
(5) Timing gears;
(6) Cam shaft;
(7) Fly wheel;
(8) Carburetion not right;
(9) Running too far advanced on the spark;
(10) Worn valve stems;
(11) Pre-ignition;
(12) Badly worn or broken rings;
(13) Piston striking some projecting point.

Locating Knocks.

Minor causes: Before making tests. first determine if the cause of the knock is not due to the minor causes, which are easy to locate:—

(1) If cylinder is free from carbon and knock is not caused by pre-ignition (see pages 233 and 639).
(2) If knock is due to running with spark lever too far advanced, (see page 68).
(3) If carburetion is properly adjusted.
(4) If valve clearance is correct.

---

*Squeaks from exhaust valves may sometimes be stopped by dropping a small quantity of powdered graphite down the guides. If the valve tappets are noisy and no adjustment is provided. a great improvement can be effected by having steel caps with insert fitted. The smallest amount of clearance between the stem and tappet should be allowed. (see Ford Instruction.)

Valve guides which are worn will often cause missing or uneven running. If worn bad they must be reamed out and a bushing fitted the correct size. see fig. 6, page 632.

**See also page 790.

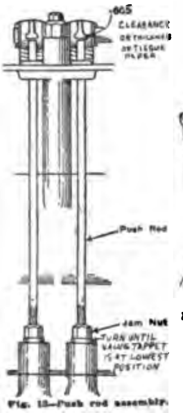

.005 CLEARANCE OR THICKNESS OF TISSUE PAPER
Push Rod
Jam Nut
TURN UNTIL VALVE TAPPET IS AT LOWEST POSITION

Fig. 13—Push rod assembly.

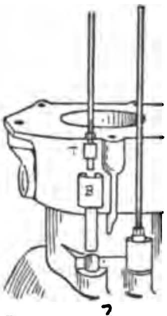


Fig. 14—Push rod and plunger removed.

Valve adjusting: To determine the proper valve clearance, crank engine by hand, turning until valve tappet has reached its lowest position.

The space between top of push rod and rocker arm should be about 0.005 inch, or thickness of ordinary sheet of tissue paper. If more, loosen jam nut and turn push rod until proper clearance is had, after which tighten jam nut.

The necessity of valve adjusting will show itself by excessive clicking of tappets and by poor running of engine.

Fig. 14 shows one of the push rod plungers removed for inspection or replacement. The pressed metal guide is fitted into a slot cut in the top of the push rod plunger, and can be removed and new rod installed if needed.

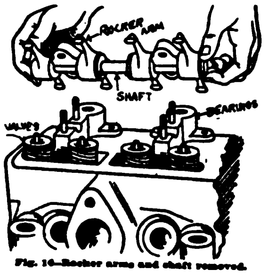


Fig. 16—Rocker arms and shaft removed.

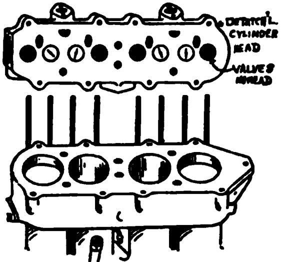


Fig. 15—Cylinder head removed.

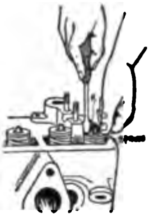


Fig. 17—Removing valve springs.

Removing cylinder head rocker-arm and shaft: Disconnect upper radiator hose connection. Remove each of the bolts holding cylinder head to cylinder casting and lift the head off. The valves, rocker arms and bearings, being attached to head, will remain with it. Now remove the rocker arms and shafts as shown in fig. 16. Before removing, bearing caps should be marked with a center punch so that they will not become mixed when replacing.

Before replacing valves it is a good plan to scrape off all carbon deposit from combustion chamber and piston. Also examine copper asbestos gasket before replacing cylinder head. If not perfect, a new gasket should be used.

When replacing cylinder head bolts turn each one until head just touches cyl. head—then tighten each one evenly—a little at the time—none should be drawn tight until all are set snug. (see fig. 10, chart 259-A.)

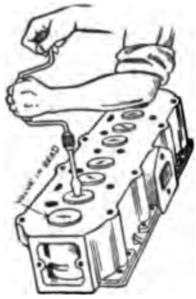


Fig. 18—Grinding valves.

Removing valve: Remove the small wire holding the valve spring cap pin in place. With a screw driver and your fingers press down upon the valve spring cap until spring has been compressed enough to admit pulling out the pin (fig. 17). Remove each valve separately, using care not to mix them in any way, as they must go back into the same valve holes.

Grinding: Secure a light coil spring and place it around the valve stem before replacing it for grinding. Smear the compound thinly on the beveled edge of the valve head and on the seat in the cylinder head. Place valve in the up-turned cylinder head and grind as shown in fig. 18.

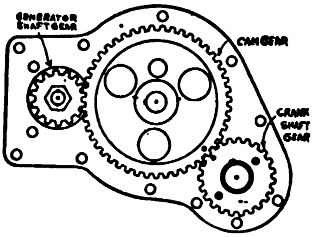


Fig. 21—Timing gear markings.

Valve timing: After having assembled the engine, with the exception of the cam shaft gear, insert the starting crank and turn until the piston in cylinder No. 1 is at its uppermost position.

By removing the spark plug in that cylinder a screw driver or rod can be inserted (fig. 19) and the position of the piston at its farthest upward movement can be determined. This is called the top center position of pistons 1 and 4.

Rotate the cam shaft so that the push rod operating No. 1 intake valve lightly touches the rocker arm. The opposite end of the rocker arm should be against the valve stem. The cam shaft gear then can be installed and properly secured.

The exhaust valve should be set up in the same way, that is, it should close at the same time that the intake valve begins to open. As the cams are integral the opening and closing of the valves on cylinders 2, 3 and 4 will come at the proper time, so it is only necessary after having secured the settings for cylinder No. 1 to adjust the push rods for proper clearance.

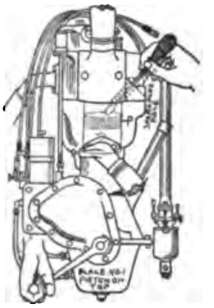


Fig. 19—Locating "Top Center" position of piston

Fig. 21—**Timing gears:** These are housed in an oil-tight compartment at the forward end of the engine. They are the **crank shaft gear, cam shaft gear and generator shaft gear.** They are lubricated by the engine. Should it be necessary to remove them, care should be exercised in replacing to see that the marks on the rims of the gears match, as shown in fig. 21. Generator gear has no marks, as it is immaterial where meshed.

Valve timing in degrees; the intake valve begins to open and the exhaust valve is fully seated, when the piston has traveled 1/16 inch or 16° below top center. Inlet closes 52° after bottom and exhaust opens 40° before bottom.

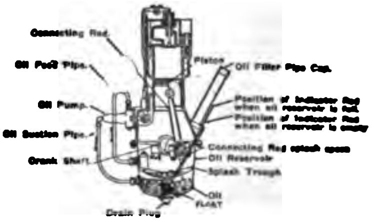

Connecting Rod
Oil Feed Pipe
Oil Pump
Oil Suction Pipe
Crank Shaft
Piston
Oil Filler Pipe Cap
Position of Indicator Rod when oil reservoir is full
Position of Indicator Rod when oil reservoir is empty
Connecting Rod splash spoon
Oil Reservoir
Splash Trough
Oil FLOAT
Drain Plug

Fig. 22—Sectional view of engine lubricating system

The oiling system is the constant splash system—see page 197. Light cylinder oil should be used, also light cylinder oil to lubricate the rocker arms and push rod felts. Keep felts saturated with oil. Oil fan often.

CHART NO. 252—Example of Valve Grinding of Overhead Valves in a Detachable Cylinder Head. Adjusting Push Rods. Valve Timing—(Chevrolet "490" as an example) see chart 179, for Timing the Ignition of Chevrolet and page 496 for Spark and Throttle control.

Chart 253 omitted (error in numbering).

After determining that the above is not the cause, then test from the outside of the engine with a sounding bar, so that the location of the knock will be determined, or at least some where near to it.

It is particularly important to learn at just what point in the engine the trouble exists, and what the cause is likely to be. With this information to start with no unnecessary parts need be removed, and much time will be saved. Aside from this, it is well known that an engine is always marred more or less by tearing down and this unnecessary expense should be avoided as much as possible.

We have often seen several good auto mechanics stand around a knocking engine, and each one name a different cause for the trouble. Taking an engine apart is a costly piece of work and often much labor and expense could be saved if the cause could be accurately located before the parts are disturbed; in fact, the knock is not always in the engine itself, although it may sound so, but may be found in some of its attachments or fittings, and could perhaps be easily remedied by the operator if he only had the means of locating it. Therefore the sounding bar plan is a good one.

After determining about where the knock is located then further testing is outlined in chart 254.

*Piston Slap.

The usual cause of knocks is mentioned in lines previous. Another knock (which is caused by loose fitting pistons) is explained in the illustration, fig. 7, chart 254, called "**piston slap.**"

This is a knock that is very difficult to locate. About the only method for locating it is with the sounding rod and removing pistons and examining them. It is apparent that this knock can occur even though the piston rings fit tight.

Piston slap is due to the piston striking first one side of the cylinder, then the other. The looser the piston is the greater the slap. If piston is a good fit, slap is negligible, which is the case in the ordinary engine. The slap may be due to **worn cylinders** or in the case of **aluminum alloy pistons it may appear only when the engine is cold,** at which time the pistons are contracted and are much looser than when they are hot.

There may be two or more distinctive piston slaps during the cycle. However, it is likely that the only one that can be heard is the one that occurs when the piston shifts from one side of the cylinder to the other at upper dead center just as the explosion is taking place, as shown in fig. 7, chart 254. **When the piston is on the compression stroke, it is in contact with the right side of the cylinder.** As the crankpin swings by dead center, the inclination of the connecting-rod is changed from right to left, thus forcing the piston to the other side. Under the full explosion pressure the piston will strike a very heavy blow when it makes the change.

The piston remains in contact with this cylinder wall throughout the stroke, and when lower dead center is reached, the pressure on it is entirely relieved, so that it is quite likely that the piston is then able to more or less float between both walls.

On the exhaust stroke the piston is thrown gently to the right side of the cylinder, due to the downward pressure of the inertia, as well as the slight exhaust pressure. It is very doubtful that this ever causes an audible slap.

The piston remains in contact with this wall throughout the suction stroke; then the downward pulling force of the connecting-rod is resisted by the suction on the piston as well as the inertia.

At very high speeds inertia may change some of the details of this explanation, but these can hardly be of interest.

Other Causes of Knocks.

The troubles which are commonly the cause of a knock that developes on a hill and which is not perceptible on level ground are as follows: Lean mixture, magneto set too early, valves seat poorly, carbon in cylinders, poor valve adjustment, loose wristpin bushing, loose magneto shaft coupling and sticking valves. The cures for these may be taken up in order. They are as follows:

Lean mixture can be cured by opening the needle valve slightly or by closing the air valve. The former is preferable as it is easier to make a correct fuel adjustment than by an exact air adjustment. This adjustment should be made on the road. Take the car out on a hill and run it up in the condition that it is at present. Return to the bottom of the hill and make a change in the mixture by turning the fuel adjustment. When this is done run the car up the hill again and note if there is any decrease in the knock. If there is none or the change is only slight it is time to pass to the next cause.

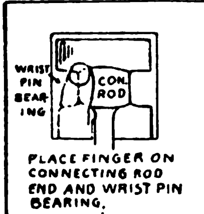
Climbing a hill with spark too far advanced will always cause a knock. (see pages 67, 68 and 491.)

The cylinder nuts if loose will cause a knock and vibration (see page 584). End play in the magneto or pump shaft and often the coupling may be loose. Lack of proper lubrication causes most of the worn-out knocks which are heard, while many come from natural wear. The timing gears, for example, run in a bath of oil and yet, in time, the teeth become worn and with the excessive backlash or play, a rattling and sometimes knocking is heard.

Knocks are frequently caused by connecting rods being slightly bent out of true (in fitting cylinders down over the pistons) —this will also cause a "piston slap."

---

*See also page 688.



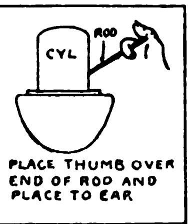
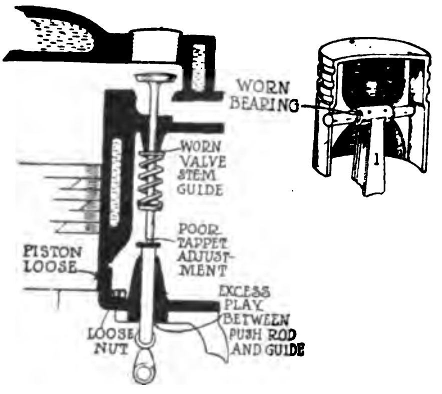


Fig. 1—To test for a knock; place finger on edge of bearing and connecting rod—have some one slightly rock engine, with switch off—the looseness, if any, will be felt. This plan can be used on Ford main bearings, but not on upper end of connecting rod, as it cannot be reached, but on some of the other engines it can.

Fig. 2.—A sounding rod (rod of iron or steel) is useful to locate source of knocks.

Detecting noise of engine by sound, with a Sonoscope. Same principle as sounding rod above. Made by Ameri-can Elect. Co., Chicago.



Places to Look for Knock.

Although not all are shown, above, most of the common engine noises and knocks are caused by either poor tappet adjustment, a worn valve stem guide, play in push rod guide, a loose piston or worn cylinder or loose cylinder nuts. Any of these will cause the engine to knock and they should be remedied immediately to prevent further complications.

Testing For Knocks.

First examine the valves: Noises from worn valve stems, push rods or guides, are usually caused by too much space between the end of the valves and push rods, and is usually the cause of most clicking noises. They can easily be detected by "testing for noisy valves" as explained on page 634.

Wrist pin knocks can be tested as follows: On some engines it is possible to reach the piston or wrist pin and place your finger on it and bushing bearings and have some one rock engine slowly with the crank; then "feel" for the looseness—if wrist pin cannot be reached, here is another plan; while engine is running, short circuit spark plugs, one cylinder at the time, to cause it to miss, while engine is running slow or idle. When doing this, if piston pin is loose there will be a noticeable knock. **The surest method** is to remove the piston and connecting rod, and test on the bench.

To test for loose pistons; remove spark plugs and put ½ pint of heavy oil in each cylinder, crank by hand slowly until oil works to the piston rings—replace spark plugs and start engine —see if the same noise occurs—if not, the heavy oil has cushioned the piston from cylinder and stopped the knock temporarily. Oil will soon get hot and run from the rings and piston and knock will occur again.

The piston, if loose, has a tendency to strike the cylinder wall, as shown in fig. 7 and explained on page 637. The rings may be tight, yet if piston is loose, this knock will likely occur.

The cam shaft and timing gears can easily be detected with the sounding rod. The timing gears will have a sound or growl that is entirely different from a knock.

When testing with the sounding bar, place thumb over end of bar and then place ear close to thumb. The closer you get to the noise the louder it will be.

To test for loose fly wheel; allow engine to run idle about 500 r. p. m., then throw off the switch and wait till it slows down to about 75 or 100 r. p. m., after which throw the switch on with spark slightly advanced. Repeat this a few times, and if fly wheel is loose there will be one distinct knock each time the switch is thrown on. **Another method in testing for a fly wheel knock is by rocking it,** (remember the fly wheel may be o. k., but some other part attached to it, such as the transmission or the clutch collar, may be loose).

A connecting rod lower bearing knock can be definitely determined by removing the hand plate at bottom of crank case, place your finger on one edge of the bearing and crank shaft. Have some one rock the fly wheel or starting crank gradually one way and the other (switch off). If loose you will feel it.

Main bearings can be tested in the same manner. A main bearing knock can also be determined when running car, by suddenly throwing into high speed or when pulling a stiff grade. If main bearings are loose, a distinct knock can be heard.

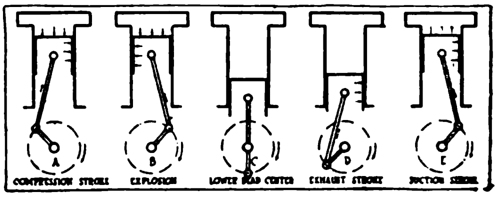


Fig. 7—Piston slap—see text page 637.

A very common trouble with aluminum pistons, which when cold contract and leave space between cylinder wall and piston. After engine is warmed up the pistons expand and noise ceases. Aluminum expands twice as much as cast iron. **The Franklin car overcomes this by cutting three slots in skirt of piston** with a spring ring placed in bottom which holds the lower part of piston to walls—as the expansion increases the ring tension gives accordingly.

CHART NO. 254—Locating and Testing for Knocks. Using a Sonoscope. Piston Slap.

A spark knock is due to advancing spark lever too far, causing combustion to take place before piston reaches top. **A gas knock** is due to excess of gas, as suddenly opening throttle wide open. This knock also results from too rapid combustion, but the gasoline we have today does not burn so rapidly as to cause a knock—**see page 161.** **A compression knock,** due to any cause which decreases the space between head of piston and combustion chamber—see page 640.

Pre-Ignition; Cause of Knocks.

It often happens that the mixture is ignited before the spark passes. This is termed "pre-ignition."

A rich mixture, or the burning of the lubricating oil, will leave a deposit of carbon on the piston head and combustion chamber. The intense heat of the explosions will heat this, and often it will remain glowing until the suction and compression strokes, exploding the mixture before the proper time—this causes a knock.

If the points of the spark plug are too thin and fine, they will get hot enough to glow in the same manner, and in such a case spark plugs with heavier points should be used.

Small points of metal, due to rough castings or other causes, should be filed down, using a fine file.

If the water circulation stops, or if the air cooling is not effective, the cylinder walls will get hot enough to ignite the charge, in which case the engine will continue to run after the ignition has been cut off. The remedy for this, of course, is to make sure that the engine is properly cooled.

Additional Tests for Knocks.

To locate the cause, first drive the car until the engine becomes warm or reaches its average temperature; second, select a run of about one-half mile, running into a grade of about 8 to 12 per cent, of whatever length may be had.

Drive the car from 10 to 15 miles per hour on the level road and maintain this speed up the grade, if possible. At this speed the engine should run quietly.

But, if, on the other hand, a slight but distinct metallic rap is heard, whether it be one, two, three, or four times to a revolution of the crank, **push rod or rods** will be found to have too much play.

Should it be a slight knock, which slightly increases as the car mounts the hill, mark this first; **worn piston rings,** which momently stand still in the cylinders while the piston travels its first 1-64 of an inch, or whatever the wear may permit, at the beginning of the power stroke. Second, it may be **worn pistons** which are being driven against the cylinder walls at the beginning of the power stroke.

This knock may instead have a distinct metallic sound which occurs once to every explosion and greatly increases as the throttle is opened or more gas is admitted into the cylinders. If this be the case mark it **carbon deposit** in the combustion chambers and on the piston heads, which becomes very hot and ignites the gas, causing **pre-ignition.**

Should the knock be either heavy or light but of a muffled sound, occurring either 1, 2, 3 or 4 times to two revolutions; this can be marked **connecting rod or rods;** which may be loose on the crank shaft, or the piston pins, or bushings may be worn. The one or more causing the knock may be located by holding down on the coil vibrator, or in any other manner that will discontinue the spark at the plugs separately. For example, if by preventing cylinder No. 1 from firing the knock ceases or is one less in two revolutions, then the trouble lies in connecting rod No. 1.

Should the engine pound, having the sound of a block of wood striking the ground, which will occur once to every explosion, but may be heavier at the explosion of any one cylinder, mark this **crank shaft main bearing.** In very bad cases this pound can be felt by the driver.

Again a flywheel that is loose on the shaft will cause the same kind of a pound (this, however, is very seldom). But if the driver will listen very closely he will discover that a crank shaft bearing has a double pound which occurs very close together, so close that when first heard it will sound like one pound.

A spark knock can be more readily felt than heard, because the power of the engine is being held back by its own ignition.

*A Seized Piston.

Occasionally the repairman receives a call to start an engine that has the symptoms of a seized piston, and has resisted the best efforts of owner of the car to start it. At such times the repairman must exercise the utmost ingenuity, for the owner has generally tried all the easy methods before he arrived.

In such cases, the first thing to do is to make sure that it is the engine and not some other part of the transmission or the rear axle that is at fault. The rear wheels should be jacked up, the emergency brake released and the gear shift lever placed in neutral. The wheels should turn freely and there should be no binding in the rear axle system.

The spark plugs should be removed, or the compression cocks opened, to relieve the compression. Then if the crank cannot be turned over by hand or by means of the starter, or by the two working together, the car may be towed with the gears in high and the clutch disengaged. As soon as the car has attained some momentum, the clutch may be allowed to engage gently, care to be taken not to allow a sudden motion which might strip the gears in the rear axle or even break a shaft.

If this does not free the engine, kerosene can be poured into the cylinders and allowed to remain for a couple of hours. This will have a tendency to dissolve any old oil which may have gummed the pistons to the cylinder walls. Then the car may be towed again and an attempt made to turn over the engine by engaging high gear. The engine can be turned over more easily in high than in low gear because it does not have to revolve so rapidly.

After one has succeeded in turning over the engine, one should open the drain cock in the bottom of the crankcase and drain out the mixture of kerosene and old oil. Then the new oil should be added, the radiator should be filled with hot water in order to expand the cylinders, and the spark plugs replaced. After starting, the engine should be run slowly under its own power for some little time, in order that the new oil may work to all parts.

***Meaning that piston is stuck to cylinder wall**—caused by excessive heat which can be due to: lack of water or lubricating oil or running a new engine at too high a speed—see pages 208, 189 and 469.

*Eliminating Compression Knock by Adding a Thick Gasket.

A knock caused by too high compression sounds like a carbon or advanced spark knock. The compression may be reduced by placing a thick gasket between cylinders and crank case.

With some makes of engines this repair is a common one, particularly when the car is equipped with a heavy closed body.† In such cases a better job may be done by making the thick gasket of cast iron. It is made in a similar manner, but must be planed or milled to a uniform thickness and smooth finish. Otherwise the cylinders will be thrown out of alignment or the joints will not be tight.

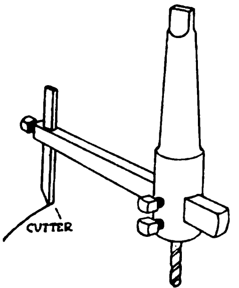


Fig. 3—Gasket cutting tool.

(1)—Remove the cylinders. (2)—Place the cylinders on a bench, and clean both the cylinder flange and engine base thoroughly. (3)—From a sheet of tin, make a template, fig. 2, which is an exact reproduction of the base of the cylinders, except that all the openings, such as piston and bolt holes are about ⅛ in. larger than those in the cylinders. The template is used as a pattern for marking out and forming the cylinder raising gasket, and permits the gasket to be made without going to the cylinder each time to see if it is being done right. A copper asbestos gasket does not have sufficient clearance to be used as a pattern. (4)—Procure a sheet of red composition board ¼″ thick.

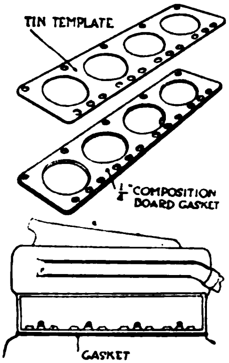


Fig. 2 — Tin template, and finished gasket. Lower cut shows gasket in position.

(5)—Using the template as a pattern, scribe out the cylinder and bolt holes, and the outside form onto the red composition board. (6)—Using a gasket cutting tool, as shown in fig. 3. and a drill press, carefully cut out the piston holes. Make these ⅛ in. larger than the cylinder bore.

(7)—Drill the bolt holes slightly larger than the diameter of the bolts. (8)—With a band saw, or key hole saw, cut the composition board to the outside shape of the pattern. (9)—Remove all burred edges with a file. (10)—Place the composition board onto the engine base, and bolt the cylinders in place, as shown in fig. 2. Shellac should be used sparingly to prevent leaks.

By doing this the cylinders have been raised, giving a larger compression space and less compression. The result is that the compression knock disappears and the engine will pull much better.

Note—It will be necessary to readjust valve rods after cylinders have been bolted down securely. (Motor World.)

Engine Bearings.

With the exception of lubrication, the most important factor in the operation of an automobile is the condition of the bearings.

The three principal kinds of automobile bearings are: Plain bearings, ball bearings and roller bearings. The most important and those requiring the particular attention of the motorist, are the engine's three or five main bearings; the four or more connecting rod bearings; and the wrist pin bearings—all of which are usually plain bearings, lined with either bronze or babbitt metal bushings.

The plain bearing: Formerly, hard steel and phosphor-bronze bushings were regarded as the best combination, but in modern practice where large bearing surfaces can be used, **white metal or babbitt** is usually employed in preference.

In the case of small bearings which must sustain a heavy shock—such as, for example, the big ends of the connecting rods—white metal is scarcely hard enough to resist the spreading action of the impact. Phosphor-bronze or a composition metal, is therefore necessary here, but where sufficient surface can be obtained to ensure against this tendency, white metal—owing to its anti-frictional properties—is generally considered preferable. Being composed largely of lead the result of a failure in lubrication from any cause is merely to melt it out without harming the shaft, which would probably occur if a tough metal like phosphor-bronze were used.

The secret, therefore, of a successful white metal bearing, or indeed a bearing of any kind, is a true and highly-polished surface on the journal. The white metal bearing can then be fitted comparatively tight, and will rapidly accommodate its surface to that of the steel, and long life will be ensured if the lubrication is correct.

The Ryerson reinforced bearing consisting of a bronze skeleton used in combination with babbitt or other bearing metals. A new type of bearing bushing.

Grooving plain bearing bushings to allow for free circulation of oil is explained on pages 203 and 644.

Ball bearings: These are very good on the main shaft, but to ensure success they should be large, (see page 109, note 1″ balls used on Stutz engine), for it must be remembered that the surface contact of a ball with its race is practically a mathematical point. For this reason they are not found to be successful as big-end bearings, for the impact is too great for such a small surface.

Roller bearings: These have, of course, a very much greater contact area than ball bearings (see page 36), and have, therefore, been found to be quite successful in big-ends, but they must be very carefully fitted, so that perfect alignment is assured. They will under these conditions stand up for an incredible time.

It might be profitable to observe here that where there is a whip, even of small degree, ordinary ball-bearings should never be used unless they are of very great size. In a short, stiff shaft with a center bearing, ordinary sizes and types are satisfactory, but otherwise double row bearings of the self aligning order should be chosen, and there are at least two reputable makers who stock this variety.

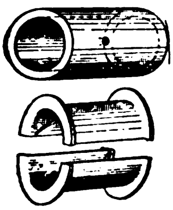
---

*See also page 627.

†To keep engine from pounding, at low speeds with open throttle.

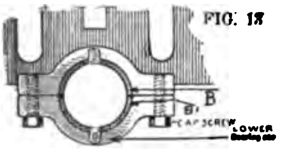
†Adjustment of Bearings.

The bearings which are most dealt with on an engine are the crankshaft main bearings, and the upper and lower, connecting rod bearings.

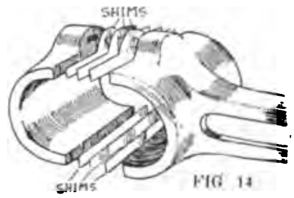


The main bearings on a **crank-shaft** are provided with bushings, upper and lower, which are made of white metal or composition alloy and are split as shown in lower illustration.

The bushings (B & B 1, fig. 13) are placed in the bearings which have between them thin metal shims, (two types of which are shown in figs. 14 and 15.) When worn, a **shim** is removed (one from each side) which allows the two bushings to be drawn closer together over the shaft.



The same principle applies to the lower connecting rod bearings, but on the upper connecting rod bearing, the bushing is in one piece, and not split (as will be noted in figure 10, page 645.) The subject of bushings will be treated more in detail further on.



Worn Bearings.

Whenever a bushing has become worn until the inner surface is no longer absolutely round, it makes itself known by a peculiar knock. On examination it will be found that the fit is loose and that the shaft has an excessive amount of "play" or lost motion and in the case of a main bearing, the shaft is out of alignment—see page 643 for crank-shaft alignment.

†Adjustment of Main Bearings.

Ordinarily the main bearing on crank shaft, if slightly loose, only requires to be taken up as most bearings are fitted with **shims.**

Taking up main bearings: first, take down the oil pan. To do this remove all the bolts underneath and all bolts at each end of pan. Then remove lower oil pan. The bearings on most engines are fitted with brass or other forms of separators of a standard thickness made up of thin shims in various gauges, .001 in. to .005 in. thick.

Shims: On modern bearings there are usually three shims of different thickness, under each side of the bearing cap. The thinnest shim being at the bottom.

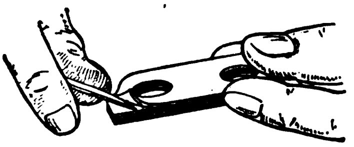


Fig. 15. The laminum shim.—note the laminated layers. In the illustration, the top layer is being started with a knife blade, enough to get a hold, then it can be peeled off.

The latest type of shim is the laminated shim shown in fig. 15. It is made of thin layers (.001 inch to .005 inch in thickness) of laminum which can be peeled off as desired. This type of shim can be used in the crank shaft main bearings and also in the connecting rod lower bearings, per page 837.

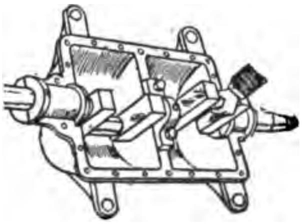
***To make proper adjustment** simply remove one or more thin shims from each side of the bearings. Be careful not to make the bearings too tight, see page 838.

The bearing cap, usually referred to as the lower bearing, must be drawn up tight. Not against the shaft but against the shim or spacing sleeve as shown at (A) fig. 3 page 643. If drawn tight against the shaft, it will burn out, and if left loose it will pound and perhaps strip nuts off the cap screws. A really mechanical job cannot be made without shims or their equivalent.

The rear main bearing is the bearing which usually requires attention first on account of weight of fly wheel and torque.

To test after taking up; turn the starting crank with pet cocks open. If you can spin the crank shaft it is not quite tight enough. It should be adjusted so moderate pressure on crank will allow shaft to turn.

Many mechanics, when taking up bearings test by getting bearings just tight enough so fly wheel can be moved. In other words after a little practice they can tell just how tight bearing ought to be by being able to barely turn crank shaft by hand, by means of the fly wheel.



To test after scraping a bearing; the crank should turn by hand but with slight resistance. See also pages 837 and 838.

Remember there is a possibility of getting the bearings too tight, and under such conditions the babbitt is apt to cut out quickly unless precaution is taken to run the engine slowly at the start.

When bearings have been taken up don't forget to see that all nuts are securely tight and the cotter pins inserted.

If the bearing is not fitted with shims, which is unusual, then it will be necessary to dress the sides of the bearing so it will make a closer fit.

All of the weight and most of the wear is on the lower part of the bearing called the lower bearing cap. For this reason there is not much wear on the top. The 1910 Ford engine did not have a bushing in top of the crank-shaft bearing at all.

---

*The bearing bushing is never scraped or removed, unless it is burnt or damaged. **See pages 203 and 644. showing oil grooves in these bearings. †See also pages 837 and 838.

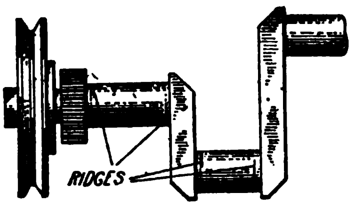


Fig. 6.—Scored crank shaft. Note the ridges. This is only a slight score. This can be polished off by encircling the shaft with fine emery cloth saturated in oil and making a steady, even motion up and down. The crank must be thoroughly washed afterwards to remove emery dust.

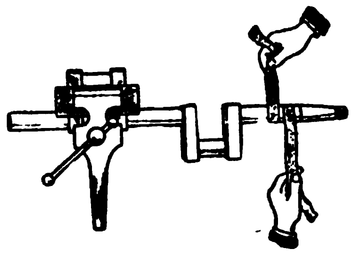


Fig. 1.—Cleaning up roughened surfaces of crank shaft with very fine emery cloth.

A Scored Crank Shaft.

When fitting bearings the crank-shaft should first be examined by seeing or feeling if there are ridges or uneven surfaces on it. If so, it will cut the bearing and cause trouble, and fitting of bearings will be a waste of time.

If crank-shaft is scored, by ridges or rings being on it, then place it between grooved wood blocks and carefully emery it down (fig. 1). Fine emery cloth in strips 1½ inches wide and well oiled should be used as shown. Emery tape is better if obtainable. Note the emery strip encircles the shaft, and a long steady movement is imparted to it in order that there is no tendency to make it oval.

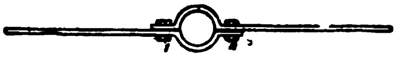


Fig. 2.—A grinding tool or "lap" for trueing up a worn shaft when proper grinding machine is not available.

If crank-pin is found out of true, by testing with calipers, that is not circular, then the best plan is to have shaft ground true on a special grinding lathe. If this is not possible, then file up the untrue part with a very smooth file as accurate a circular shape as possible, testing frequently with the calipers. A lead "lap" is then made in clamps (fig. 2). This is bored out to a size, and paper or card shims inserted between the two halves so that the two halves can be gradually closed down by the bolts onto the crank-pin. This lap is dressed with fine emery and oil and worked around the crank-pin by hand till a good surface is obtained.

*Scraping and "Spotting In" Bearings.

The bearings on a crank-shaft are the lower connecting-rod bearings and the bearings which carry the crank-shaft, called the main bearings. In modern engines these are usually babbitt or white brass or some similar metal which is soft, easily cut and tough. To scrape in a set of bearings usually requires 12 to 20 hours, depending upon bearings not being out of line.

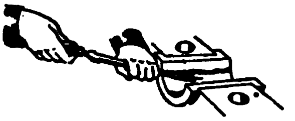


Fig. 4.—Using a scraping tool on a bearing surface.

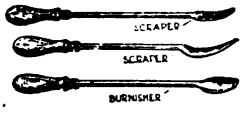


Fig. 3.—Bearing scraping tools which can be secured at any supply house or made of old files.

Connecting-rod bearings: After sufficient shims have been removed from between cap and rod so that bearing fits tight on shaft, the rod nuts are taken off and the **shaft** bearing surface given a very light coating of "marking" compound.

The marking compound is Prussian blue which can be secured at any supply house and comes ready mixed. A **little** dab on the fingers is sufficient to wipe on the shaft as a very light coat is required. If too much is given it will run all over the bearing and spots will show which should not be scraped.

Marking or "spotting-in" bearing: Put connecting rod in place, put on cap and draw up tight. Be sure caps are fitted on according to the punch marks on cap, and rod is on right side forward. Then rock back and forth and swing it around shaft twice.

Next remove nuts and bearing. The "high spots" inside of bearing will be found marked in blue, showing that at these points the crank touched, but the part which is white, the crank did not touch. Therefore, the problem is to get the high spots down until the bearing will mark all over, by scraping, which is a slow, tedious job, for if too much metal is removed it cannot be replaced.

This marking or "spotting in" process is repeated from time to time till the whole surface is marked as shown in D, fig. 8. In practice it is not possible to get every white mark off the bearing, and if say, not over one-tenth of the total surface, let it go, it will wear in.

Adjustment: When scraping is completed and all nuts down, the rod should be just stiff enough to turn by hand and if placed in a horizontal position it should not fall by its own weight, but should move when pushed by hand. If fitted too tight seizure will result.

After the scraping is done the burnisher shown in fig. 3 may be run over the entire surface of the bearing to shine it up and smooth the surface.

The scraping tools can be made of half round files as the quality of steel and temper is just right—or purchase at a supply house.

The rod bearings should now be tested for parallelism (see pages 659, 646, 649). The piston pin and the crank-throw must be parallel, and the bearings that they move in must also be parallel, or binding and rapid wear will take place.

If the small end bearing of the connecting rod is worn it will be necessary to make a new bush and ream it out to a true fit on the piston pin to about .002 inch clearance (see foot note, page 645).

Scraping main bearings, see page 643.

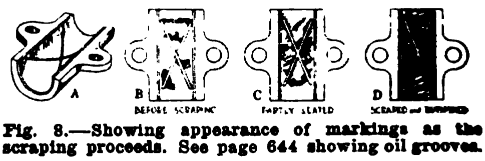


Fig. 8.—Showing appearance of markings as the scraping proceeds. See page 644 showing oil grooves.

CHART NO. 255—Scored Crank Shaft. Scraping Bearings. *See pages 837, 838; fitting bearings.

—continued from page 641.

If bushing is cut or burnt, then it can be scraped and replaced as explained below, or a new metal bushing with shims can be fitted, drawn up and run until worn in—using plenty of oil.

****Draw filing:** The two bearing halves can also be brought closer together, by draw filing (fig. 8), the lower part of main bearing cap. It is clear, however, that this does not make the bearings exactly round, so that it will have to be "fitted." This is done by scraping.

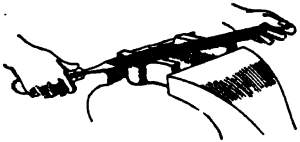
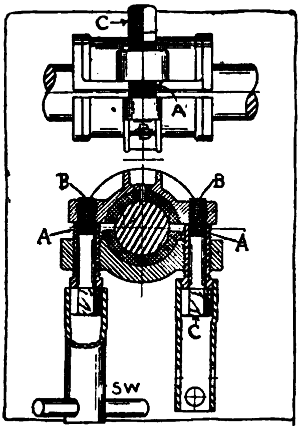


Fig. 8—In filing down the bearing face, hold the file in this position, and draw it across the face with the left hand. Do not attempt to file on the return stroke.

Adjustable Bearings.

Unlike most engines, the Reo main bearings are adjustable from the outside, and it is only necessary to remove mud pan to reach them. A, are spacing sleeves and B, are locking studs. Take up bearings with socket wrench (SW) until shaft turns a little bit hard.

Connecting rod bearings are adjusted through the handholes in the side of the crankcase. **Connecting rod lower ends** are "hinged" on the Reo.



†Scraping Bearings and Crankshaft Alignment.

Scraping the connecting-rod bearings and how to test by "spotting-in" the bearing is explained on page 642. Scraping is resorted to when a bushing is burnt or damaged.†

The adjustment and fitting of main bearings is also explained on pages 837 and 838.

Before marking or scraping the main bearings, each bearing cap is to be set down tight with the nuts and tried for tightness, the other bearings being loose at the time.

To scrape the main bearings: The upper bearings are finished first, therefore crank case is laid up-side down, per fig. 2, page 646.

All the upper main bearings are worked at one time, so that the shaft will align.

***Crank shaft alignment:** Very likely the center bearing will be high and the shaft will rock on it. If so, it will have to be scraped down till there is no rocking and until all the bearings mark all over. Great vibration as well as wear, can be caused by neglecting this. If center bearing is too low, which would be shown by no marking at all, then the end bearing will have to be scraped out till the center bearing marks all over.

In marking or "spotting-in" these bearings the weight of crank shaft is sufficient. Do not put on the caps at all as they would force or spring the shaft down and mark the low part of bearings.

The cap or lower main bearings (after upper bearings are completed) are treated in a similar manner as the connecting rod caps, page 642. They are scraped down to a perfect marking. **A very important point is to "spot-in" and fit the rear cap first and test it for stiffness then loosen it, then "spot-in" and test the next and loosen it and the other the same. After doing this then tighten down on all. Otherwise, if each bearing is tightened as you proceed, the bearing being fitted could not be properly tested for clearance.**

After "spotting-in" main bearings, caps are tightened down and "run-in" by belt power, using plenty of oil. Caps are then removed, bearing surface examined, then replaced and proper clearance given by removing a shim, if necessary.

Adjustment; when lower caps are fitted and nuts drawn up tight, the shaft should turn with some resistance. Some repairmen judge the amount of resistance by being able to move the crank shaft with one hand (per page 641), or if bearings are being taken up under engine, by just being able to move or turn fly wheel. The bearings must **not be so tight they will overheat** and seize.

If the shaft turns too hard, do not think that loosening up the nuts is the remedy. In such a case an extra thickness of shim brass will have to be put in so that nut can set down tight and still allow shaft to turn.

Connecting rod lower bearing is often "burned-in," by fitting new bearing caps and then run on power for a few minutes, then cap is removed, surface examined to see if cut, if so it is scraped, then correct clearance given with shims (.003 to .004").

Connecting rod upper bushing is usually refitted with new bushings and reamed to .002 to .003" clearance.

Bearing Pointers.

After fitting bearings, run engine at moderate speed for first 500 miles, using plenty of good oil to work bearings in. See also page 793.

Before marking and after scraping, dust metal chips out with a small paint brush.

See that oil grooves are not clogged and are deep enough (see page 644).

Wash all parts off with gasoline or kerosene.

Have the scrapers sharp and never try to scrape with nicked scrapers.

In renewing bearing bushings, care must be taken that they are of about the same thickness of metal, as the original ones. If too thick the pistons will be pushed higher into cylinder and alter the compression and cause vibration. On two-cycle engines it would change the port timing.

***A Reamer**, per page 792, fig. 66 is used extensively for aligning crankshaft. **See also page 708, for draw filing.

†**Bearings are also sometimes ("burned-in" or "run-in"), where a quick job is desired,** by fitting new bushings, one at the time, then bearing caps are drawn tight, then belt power applied until worked in. The caps are removed, bearings inspected and high spots scraped down, proper clearance given by removing shims, if necessary and caps then fitted. It is always **best** to scrape a bearing and spot it up first, however.

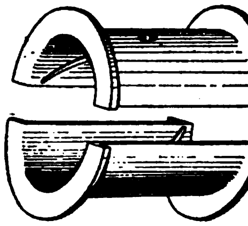


Fig. 7—A split bushing for lower end of connecting rod.

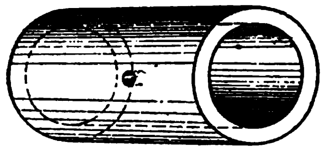


Fig. 6—Bushing for upper end of connecting rod.

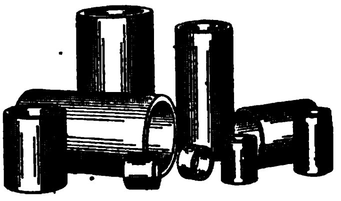


Fig. 8—Bronze bushings needed in every repair shop. Can be secured at brass foundry. Call for "bearing bronze."

Bearings.

Strictly speaking, the bearings of a shaft are composed of two different metals. The real bearing is cast integral with the engine or machine of which it forms a part, and the other part (on which the shaft really bears) is known by various names, such as linings, bushings, brasses etc. They are made of various metal, such as babbitt, phosphor-bronze, white metal alloy etc.

The adjustment and replacement of bearings in an engine, or some part of the transmission, such as a gearbox, is a matter requiring a good deal of skill and experience to effect.

With the exception of the small end of the connecting rod (figs. 1, 2, 3) all bushings are split lengthwise (fig. 7). The small end of the connecting rod has a plain phosphor bronze bush (fig. 6) forced in fairly tight. When worn, a new bush is fitted which is turned and bored to a free fit without any trace of rocking or end movement.

The split bushings (fig. 7) in time wear oval, mainly on the lower half. In most cases a slip of metal called a "shim or liner" is inserted between the upper and lower halves of the bearing, which pieces can be filed down or one or more layers peeled off, (if laminated shims are used) for adjustment.

Many bearings are "lined" or bushed with "babbitt-metal," bronze or anti-friction alloy. When worn, the bearing halves are relined and bored out true. The surface is tinned and the molten metal run in either solid to fill up the bore completely or around a mandril smaller than the shaft. A true bore to fit the shaft is then made in the lathe and the bearing cut through, after which the necessary oil channels are cut in the surfaces. (see figs. A and B below.)

FIG 1

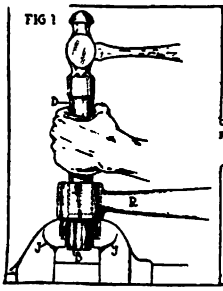


FIG 2

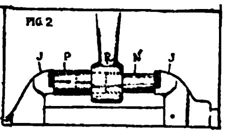
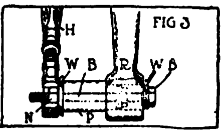


FIG. 2—BUSHING REMOVED WITH VISE

FIG 3



Piston or Wrist Pin Bearings.

Fig. 1—One common way to remove a bushing. Jaws J of vise are opened far enough so end of rod R rests upon them and at the same time give sufficient clearance for bushing to pass between as it is driven out. To drive out bushing B, a drift D (usually bar of steel) and a hammer are required.

Fig. 2—A better way; jaws J of the vise are opened wide, a piece of pipe P, large enough to clear the bushing, is placed against the inner surface of one jaw, the rod is carefully adjusted and pressed against it to hold it in place until the drift or solid pin N is adjusted into place, then draw vise together to squeeze the bushing out of the rod R into the pipe P. If no vise is at hand with a large enough opening, recourse can be had to method shown in fig. 3.

Fig. 3—Another plan; a bolt B, some washers W, a piece of pipe P, a nut N, and a wrench H may be employed as shown. By this method, a bushing may be removed without danger of springing or burring up connecting rod end.

To remove a tight piston pin, first extract the locking rings, then plunge the piston in boiling water. This will release the grip of the piston on the pin and permit it to slide out.

When a bearing is adjusted, it must also occupy the same relative position as before in its bed, and to effect this, packing the lower half with very thin sheet phosphor bronze or foil may be necessary. Various thicknesses from 1-1000 inch up can be obtained for this purpose. A good practice is to slightly "ease off" the bearing at the dividing line, to avoid any risk of binding.

It is of great importance to the running of a bearing that the shaft be dead true and cylindrical and the surface quite smooth.

When fitting a plain bush (fig. 6) very moderate pressure should suffice to drive it in place. A tight fit may cause the bush to bulge, necessitating reaming out to make it fit.

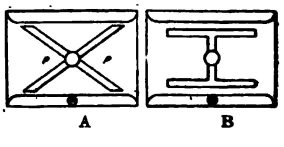
A bush that is an easy fit requires dowel pinning to prevent it turning round. Particular care should be given to cutting oil channels, and to note, in the case of plain bushes, that the oil holes are drilled all the way through.

Hardened steel bushes can be used, providing the shaft is case-hardened to resist wear.

This type of bushing requires grinding after hardening, and the running clearance should be a shade more than for phosphor-bronze. Ample oilways should be cut in the surface as per B, below. (see also page 203).

Oil Grooves in Bearing Bushing.

Another important feature is the shape of the oil grooves themselves. The usual practice is to make the grooves as shown in the figure at A, like a letter X. The result of using this style of groove is that the areas of the bearing at p,p, run dry. A careful series of tests has shown that the type of oil-groove shown at B and made in the form of the letter H, gives results far superior to the other. Some very bad cases of poor lubrication and heating bearings have been cured entirely by the simple expedient of changing the type of oil groove from that shown at A to that shown at B. (E. W. Roberts in "The Gas Engine.")



Keep oilgrooves out of the pressure side of your bearing, whenever the pressure is one sided, as in the crank-pin bearing. —see also page 203.

CHART NO. 256—Bearing Bushings. Wrist or Piston Pin Bushing Removal. Oil Channels.

*Piston or Wrist Pins.

The piston or wrist pin is the pin on which the upper part of the connecting rod swings. It is sometimes made of solid steel but usually of hollow case hardened steel tubing. It is also called ''gudgeon'' pin. It is non-adjustable, therefore when worn the pin or bushings must be renewed.

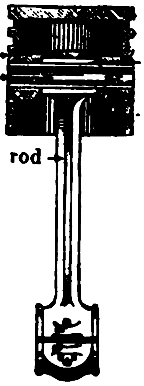


Fig. 10—Piston pin is stationary — note the bushing is in upper end of connecting rod.

The stationary piston-pin, fig. 10, has a bronze bushing in the end of connecting rod which oscillates on the piston pin. The pin is held tight by a set screw.

Oscillating piston-pin is where pin is clamped to upper end of connecting rod, as C, fig. 11. The **bronze bushing in this instance is pressed into bosses in piston** and piston pin oscillates in the bronze bushings.

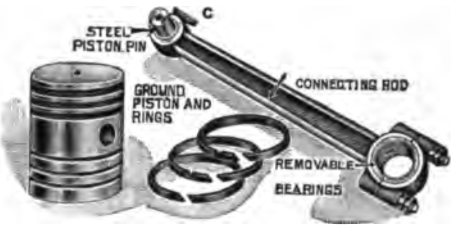


Fig. 11—Piston pin oscillates in bushings in piston bosses. Note connecting rod is clamped to pin at C.

To remove piston pin when stationary, see page 650, fig. 22. Another method for holding the pin in place is by means of a spring pressed plunger which is in the inside of the boss inside of piston. To remove pin in this instance a small wire forces plunger up and pin is driven out.

To remove bronze bushing in upper end of connecting rod or piston bosses is sometimes a difficult task (see figs. 1, 2 and 3, page 644 and fig. 22, page 650). Quite often a reamer is used to ream them out. The idea is to renew the bushings.

The piston pin may also be worn, therefore examine and replace it when renewing the bushings if worn. **As a rule, wrist pin and connecting rod bearings are apt to wear soner than the main bearings.** Therefore test for looseness per page 639 and below, before working in the bearings.

**Connecting Rod—Lower Bushing,

To test to see if a connecting rod is loose: remove lower crank case. Take hold of rod and see if there is end play, by a vigorous push up and down, if so, the looseness can be felt.

Don't mistake the side play however for the looseness, as a slight amount of **side play is necessary.**

The connecting rod, lower end is divided into two parts, usually with shims placed between, see fig. 14, page 641.

What has been said in the reading matter, concerning the main engine bearings also holds good for the connecting rod bearings. The two bearing halves may be brought closer together by the removal of some of the ''shims'' between them or dressed down with a file, if shims are not provided. It is policy to take off enough metal to allow for a few shims, so that when taking up is again required, it will only be necessary to take out 1 or 2 shims—see page 838.

In the majority of engines the removal of the lower half of the crank case is necessary before the connecting rods can be reached.

Note that there must be about $\frac{1}{16}$ inch side play between the sides of the connecting rod bearing and side of crank shaft arm—also at upper end. (see pages 659, 646, 649 for aligning connecting rods.)

Pistons.

Pistons are made of cast iron for all ordinary uses. In many instances where speed is desired, an aluminum alloy called ''Lynite'' is being adopted.

The cast iron piston expands less than steel or aluminum alloy pistons. The latter expanding under heat more so than cast steel.

The piston proper, is made with grooves for rings, which are generally placed on the upper portion as shown in illustration on page 74, also fig. 6, page 649.

In many instances the piston also has a ring below the center.

The average piston is fitted with three rings. Quite often there is an oil groove cut in the piston at the bottom or piston skirt, which improves the lubrication materially. see fig. 6 page 74 and page 202.

Where speed is desired, the lower part of piston is frequently drilled with holes and piston is made of aluminum alloy to lighten them as much as possible (see index ''Tuning an engine for speed.'')

‡Aluminum Alloy Pistons.

It is claimed by manufacturers of same to be superior to cast iron for the following reasons: They are about one-third lighter. The inertia of the reciprocating piston is reduced approximately 67 per cent. This cuts down side pressure or thrust on the walls of the cylinders and reduces friction and the consumption of lubricating oil. The great heat conductivity of aluminum alloy

—continued on page 651.

***The piston pin bushing** is usually a bronze bushing pressed into place and in case of renewal will have to be driven out per pages 644, 650. **If piston pin becomes loose** it will score cylinder, per page 653. †Oldsmobile Co. recommend .002" clearance in upper end of connecting rod which is necessary to take care of different expansions between bronze and steel when heated. **See also pages 837 and 838. ‡Foot note, page 651.

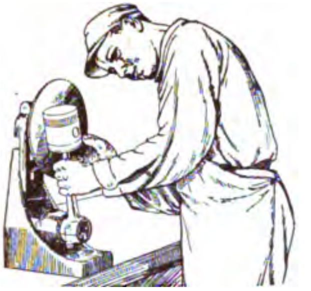


***Fig. 1.—Testing connecting-rod.** A jig or fixture for testing the alignment of connecting-rod assemblies is shown. The crank bearing of the connecting-rod is attached to an arbor that is part of the base, and the piston swung across the face of the disk that is fastened to an upright. This disk is made similar to a face plate and is necessarily at right angles to the crank bearing arbor. Any misalignment is instantly detected and corrected by bending the connecting-rod so that the side of the piston forms a line contact with the surface of the disk. This prevents the possibility of unequal wear of cylinders due to off-center pistons—(Motor World).

Fig. 2.—Crankshaft testing. The crankcase may be used as a fixture for testing the alignment of the main bearings of the crankshaft with little difficulty. The case is placed on the bench in the position shown, a strip of pasteboard about 1 in. wide and 1/64 in. thick placed beneath the front and rear bearings of the crankshaft. By these the shaft is raised from the center bearing and side play prevented. A pointer is then clamped onto the side of the case at the center bearing, and by turning the shaft the amount it is out of true is determined. This method is not only better but quicker than testing in a lathe.

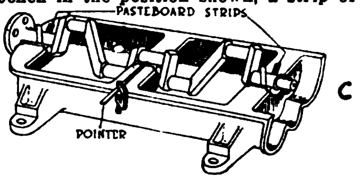


Fig. 4.—Removing pistons is necessary when working on the wrist pin.

The method of removing piston (Overland for example) is to take off the bottom half of the crank case and then remove the connecting rod bearing cap from the rod attached to the cylinder which it is desired to remove. The bearing cap is held by two bolts fastened by castellated nuts. When these are removed the rod can be swung to one side out of the way of the crank shaft and the entire assembly withdrawn from the cylinder in the manner illustrated, fig. 4. The piston pin can then be driven out with a punch after which the bushing can be readily removed.

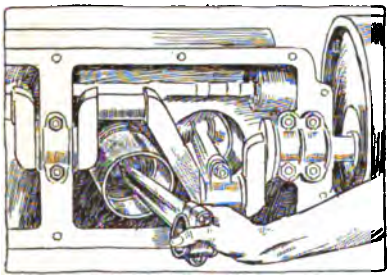
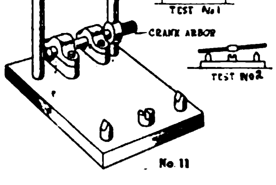


Fig. 4—Method of withdrawing piston and connecting-rod assembly after the bottom half of the crankcase has been removed

This plan however cannot be used on engines where the pistons are too large, or a 5 bearing crank shaft or on a 6 cylinder engine. The procedure is then to remove the cylinders and lower part of crank case and loosen the connecting rod caps and take pistons from top of cylinders, or it may be necessary to raise cylinders from off pistons.

***Fig. 11. — Connecting rod alignment:** It is essential that the two bearings of the connecting-rod be in perfect alignment. Not only should they be parallel, but they should also be in the same plane. The jig illustrated is designed to test these with one setting. The connecting-rod is held on an arbor, and a second arbor placed in the wrist pin bearing. Knife edges are used to check the alignment of the two arbors, one pair for parallelism horizontally, and one for vertical parallelism, the rod being swung from one test position to the other. (Motor World.)



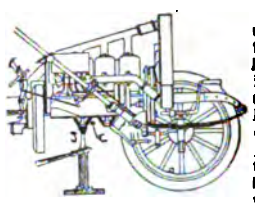


Fig. 3.—One method for testing for a loose bearing is shown in the sketch. Run the car over a pit, if possible, although the bare floor will do.

Raise the car by means of a jack to suit the conditions for testing. If the rod bearings are to be tried, run a jack head against the lower half of the connecting rod bearing and work the jack handle up and down. The smallest amount of play can be detected in this way, especially on the main bearings, where the presure of the jack is applied on the crank shaft against the weight of the car and "play."

Figs. 5 and 6.—One method of straightening a slightly bent crank shaft is shown. This shaft is bent as indicated by the dotted line, A, fig. 5, only to a very much less extent, the bend not being visible to the naked eye except when the shaft is revolving in a lathe with a tool or other object held stationary, close to the center bearing surface.

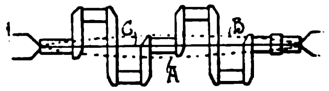


Fig. 5—Bent crank-shaft.

In testing for a bent crankshaft, one should not be misled by a bearing surface of the shaft that is probably worn out of round; the test should be made at the side of the bearing where little or no wear is liable to take place.

There are few repair men who will undertake to straighten a bent crank shaft, and by many it is claimed to be impossible to make a lasting repair to a shaft which is out of true. However, as the repairman is occasionally called upon to fix-it-up, one means employed is **shown.**

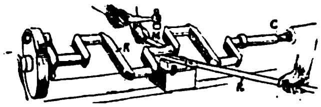


Fig. 6. Method of straightening.

The shaft K is fixed between the centers C of lathe, blocks B, are placed upon the lathe-bed for a fulcrum, and a bar of iron R, or preferably of wood, is used as a lever. If an iron bar is employed a piece of brass, wood or lead should be placed between it and bearing surface of shaft for protection.

Assuming that the shaft is bent as indicated by the dotted line A, fig. 5, it is pried up with the bar till it assumes the position indicated by the dotted line B. and while held in this position an assistant holding a piece of brass, M, on the bearing surface with one hand, and with a hammer in the other, strikes the shaft a sharp light blow.

The bar and blocks are then removed, the lathe started, and the shaft tested again for results. This treatment is repeated again and again until the shaft is straight as indicated by the line C. It is generally a long and tedious job, depending greatly upon chance and the ability of the operator of the bar to guess the proper amount of pressure to apply and the proper place to apply it.

HART NO. 257—Testing Connecting Rod and Crank Shaft Alignment. Straightening a Bent rank Shaft. Testing for a Loose Bearing. Removing Pistons.

---

*See also, page 659 and foot note page 649.

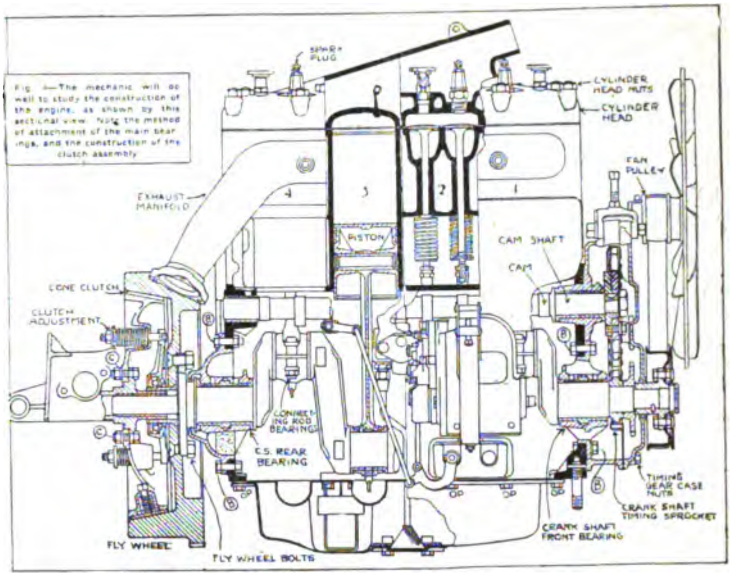


Fig. 4—The mechanic will do well to study the construction of the engine, as shown by this sectional view. Note the method of attachment of the main bearings, and the construction of the clutch assembly

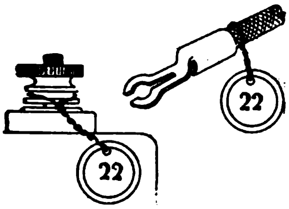


Fig. 1—All terminals should be marked in some simple manner, to facilitate the assembly. Price tags are used in the above method

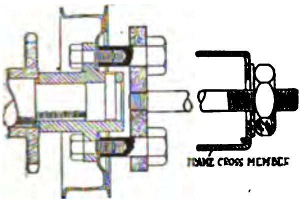


Fig. 2—Special puller for removing the fan pulley flange from the crankshaft. It may only be used when the engine is in the car, and is attached to the flange bolts

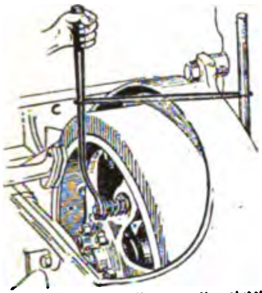


Fig. 3—All operations on the clutch springs are made easy by the aid of the compressor shown. It consists of a forked lever, held by a steel wire to a rod braced on the engine support. The forked lever is also an effective tool for removing valves

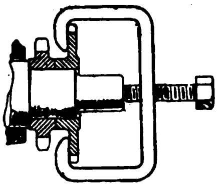


Fig. 5—All injury to the timing sprockets is prevented by the use of this puller. It can only be used after the timing cover and chains are off

The following outline of work will give the reader an idea as to how to use system in connection with repair work. While the example treats on main and connecting rod bearings, still the main features and manner of doing the work will apply to other work of a similar nature. There is a right time and a wrong time to remove each part. The following order has been found the most efficient by the Overland Service Station in New York and was published in "Motor World," a leading automobile publication.

Indications of Wear.

Heavy, dull pound—main bearing.

Lighter knock, usually worse when engine is idling—connecting rod bearing.

(Inspection of the bearings is always essential before taking the engine down, as the trouble may be somewhere else.)

How to Determine Where?

1–Remove pan.

2–Remove hood.

3–Draw oil from base.

4–Remove base.

5–Place jack beneath flywheel, and work it up and down. Any play may then be felt in the main bearings, see fig. 3, page 646.

6–Work connecting rod bearings up and down, to determine looseness.

Note—A chain or tackle block, secured to the ceiling, is necessary to remove the engine from the frame; and some sort of a stand to rest it on when removed. These, the standard shop tools, and the few special tools described later, are all that is essential to efficient work. If the connecting rods only are loose, they may be tightened without removing the engine from the frame. Looseness in the main bearing necessitates a complete removal and tearing down of the engine.

1–Find the trouble.

2–Study the location of the defective part, and its relation to other parts.

3–Determine the commonsense method of getting at the defective part—and do not remove any part unnecessarily.

4–Lay out, either in your mind or on paper, the successive steps necessary to do the work. Efficiency demands that you do all possible work on one part from one position.

5–If necessary, mark each part on removal.

6–Place each part as it is removed, in some systematic order, either in a parts box or on the bench.

7–Check up each part on re-assembling, and make certain that all nuts are tight.

To Remove Engine.

(Note—Have you got the common tools necessary to do the work right where you can get them instantly, or are you going to spend half your time running for them?)

1–Drain radiator.

(This will be draining while you remove the lamps.)

2–Remove lamps.

3–Remove radiator hose connections, brace, and retaining bolts.

4–Remove radiator.

5–Remove all wiring terminals marking each one as shown in fig. 1 so that they may be returned to the proper binding post.

6–Remove throttle and spark control, connecting steering post with engine base.

7–Remove oil pipe connections, and gasoline pipe, after turning off gasoline.

8–Disconnect exhaust pipe from manifold.

9–Remove torsion tube yoke pins from yoke.

10–Remove bolts from universal casing.

11–Remove fan belt and pulley retaining nuts on crankshaft flange.

12–Remove fan belt pulley on crankshaft, using special puller shown in fig. 2.

13–Using rope sling, and chain blocks, hoist engine forward, removing it from frame.

—see next page.

CHART NO. 258—Example of Fitting Main and Connecting Rod Bearings of Overland Model 75—Continued in chart 259. (Motor World.)

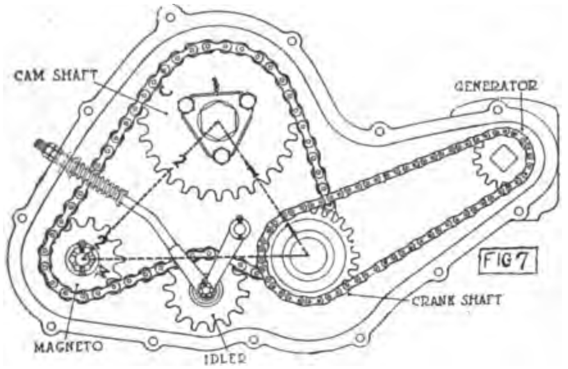


FIG 7

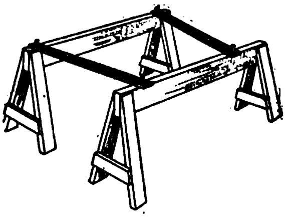


Fig. 6—Accessibility is essential in engine repair and necessitates some sort of a stand. After removing the crank case base and the cylinder head, the stand illustrated may be used to hold the engine upright or bottom up.

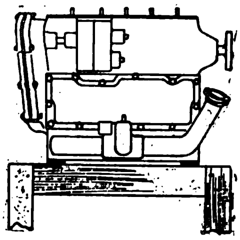


Fig. 8—Engine (bottom side up) bolted to horses.

—continued from chart 258.

14—Drop engine onto two horses, connected by iron straps, as shown in fig. 6.

15—Remove clutch spring bolts as shown in fig. 8.

16—Remove 8 bolts holding rear support to engine base, and take off entire assembly.

17—Remove clutch.

18—Mark flywheel and crankshaft flange with center punch, so that it may be returned as taken off. Remove flywheel bolts and flywheel.

19—Remove cylinder head.

20—Remove connecting rod bearings, marking both rods and caps so that they may be reassembled exactly as taken off.

21—Remove connecting rod and piston assemblies.

22—Turn engine bottomside up, and fasten to horses, as shown in fig. 8.

23—Remove timing gear case, exposing timing gear and chain.

24—Turn crank until front and rear throws are at top dead center. The distributor should then be making contact with No. 1 brush. If not, turn crank over once. Then mark face of gears as shown in fig. 7 if this has not already been done.

25—Using puller shown in fig. 5, remove crankshaft sprockets.

26—Remove front crankshaft bearing assembly bolts.

27—Remove rear crankshaft bearing assembly bolts, and draw crankshaft out towards the rear. (By careful inspection, get some idea of the actual amount of looseness in the bearings; then remove the bolts holding the halves together, completing the tearing down.)

The Repair.

(Note—The work of refitting bearings is tedious even for the best mechanic. Do not expect to fit one bearing in less than two hours, if it is badly worn; and do not be disappointed if the bearing seems to get worse instead of better at the start of the scraping process.)

1—Carefully file a small amount of metal from the face of each bearing cap. To do this, clamp the bearing in a vise and holding the end of a fine flat file loosely between the left thumb and forefinger, the right holding the handle, draw the file with the left hand across both edges of the bearing cap, per fig. 8, page 643. Do not remove more than .002; try the bearing, and if still loose, file again.

2—Clean both shaft and bearing with waste, wet with gasoline.

3—Paint the shaft with a solution of Prussian blue and water. Allow to dry.

4—Clamp bearing halves together on shaft, and turn three or four times with the hand.

5—Remove. The high points in the bearing will be blue, and must be scraped down.

6—Again clamp the bearing to the shaft, and repeat blueing, scraping and testing, until the bearing is properly "spotted in." When spotted in, but litle of the bearing half will be untouched by the scraper. An equal amount of material must be removed from each bearing half; and when properly fitted, the shaft will register contact over practically three-quarters of each bearing half.

7—Replace bearings, after oiling, and be sure that they do not bind. A small amount of binding may be removed by poening down the caps of the bearing with a hammer. When right, the bearings should be free enough to be turned by hand without great effort.

8—Check up the alignment of each piston with its rod and bearing, by the use of a ground arbor and square, fig. 9, (page 649.) see also chart 257. With a micrometer or calipers, check up roundness of connecting rod bearing on crankshaft; and if out of round, the best practice is to send them to a specially equipped shop for regrinding.

9—Replace crankshaft and crankshaft bearings.

10—Replace flywheel, making certain that it is replaced exactly as removed.

11—Replace No. 1 connecting rod assembly, and remove shims, until bearing binds. (This assures that there will be sufficient material to permit scraping to a seat.)

12—If binding is excessive, and the crank cannot be turned, replace one pair of shims, after fling.

13—Clean shaft and bearing, paint shaft with Prussian blue, and proceed with scraping as with main bearing.

14—When bearing is properly spotted in, oiled and tightened, an even resistance should be felt when turning the crank. (First hard, then easy turning indicates a poorly fitted bearing or an oval crankshaft. Again check with calipers.)

15—Scrape and tighten each connecting rod bearing in turn, having the others loose while so doing. And be sure to follow the marking placed on the rod and bearing, so that each assembly is replaced exactly as it came off.

The Reassembly.

1—Make certain that all nuts are tight, and that all cotter pins are in place.

2—Soak every bearing with cylinder oil.

3—Replace sprockets on front end of crankshaft, using a lead hammer, brass punch, or wooden block.

4—Turn crankshaft until pistons 1 and 4 are at top dead center.

5—Turn camshaft sprocket until point (1), fig. 7, comes opposite point (1) on the main sprocket.

6—Turn magneto sprocket until point (2) lines up with point (2) on camshaft sprocket. Distributing brush should now be in contact with cylinder of No. 1 terminal.

7—Wrap chain around sprockets and fasten the master link.

8—Replace timing gear case. Use shellac in replacing gasket.

9—Replace fan pulley.

10—Replace fan bracket and belt.

11—Slide clutch into place.

12—Replace rear engine support and bolt into place.

13—Replace clutch springs, as shown in fig. 8.

14—Replace cylinder head. See fig. 10, page 649.

(Note—Carbon should be scraped out, and valves reground and adjusted first).

HART NO. 259—Continuation of Chart 258. Fitting Bearings. (Overland.)

—continued from chart 259.

15—Replace base. Use cork packing, and shellac only one side.

16—Swing engine back into frame.

17—Holding drive shaft up, slip universal into place. The block and tackle are required for this job, and at least two men are needed; one to guide the universals, and one to manage the engine.

18—Replace universal yoke.

19—Bolt universals together.

20—Bolt engine to frame—and make sure retaining bolts are tight.

21—Replace pedal mechanism, brake rods, etc.

22—Connect the exhaust manifold.

23—Connect oil and gasoline connections. Turn on gasoline.

24—Connect wiring terminals. Make certain that marks are followed.

25—Replace radiator and radiator hose connections. Use rubber cement on all joints.

26—Replace controls from steering column to dash.

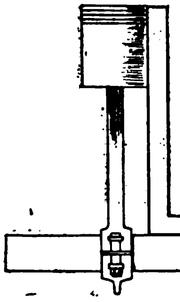
27—Refill radiator.

28—Place 9½ qts. of medium oil in base.

29—Spend 5 min. checking through all nuts, bolts, screws, pins, etc.

30—Start engine. Do not use starter, but crank by hand, or tow car while locked in high, if extremely stiff. If engine will not start after a reasonable amount of cranking, inspect wiring, gasoline and spark. But do not continue to crank blindly. When started, do not allow engine to race, but allow it to run slowly for a period sufficient to remove some of the stiffness.

31–Replace pan. 32–Replace hood. (from Motor World))



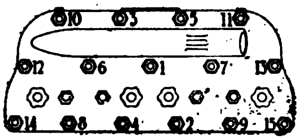


****Fig. 9 (left illustration). A ground arbor and a square should be used to check up the alignment of the connecting rod and piston assembly.** This should be done both before and after scraping the bearings.

Fig. 10 (right illustration). In replacing the cylinder head, tighten the stud nuts in the order shown above. This will avoid warping or springing the cylinder head, and assure the tightest possible fit. No nut should be drawn clean down before all are set snug.

How To Measure Piston and Ring Clearance.

Method of measuring piston clearance: Place "inside micrometer" (1M) in cylinder per fig. 2, and determine inside diameter of **cylinder.**

FIG 2

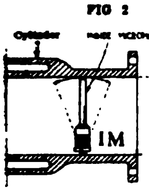


FIG. 3

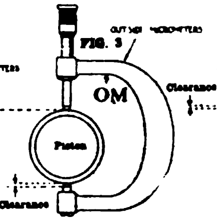
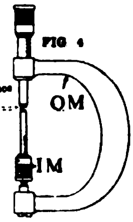


FIG 4



*Then place an "outside micrometer" (OM) over piston, per fig. 3, to determine outside diameter of **piston.**

Then place the inside micrometer (1M), fig. 4, as shown, in between the outside micrometer, and note the clearance.

Method of finding ring clearance in opening of ring: Place piston without rings into cylinder. Then slip ring into cylinder behind piston, as shown in fig. 5. Pull piston up against ring in order to square ring up in the cylinder.

A †thickness gage is then applied as shown in fig. 5 and distance determined. As a general rule the clearance should be .004" per inch of cylinder diameter. This rule does not hold on patented rings as the Leak-Proof ring clearances are as follows:

2 to 3" diam., .010" opening.
3 to 4" diam., .016" opening.
4 to 5" diam., .018" opening.
5 to 6" diam., .022" opening.
6 to 7" diam., .026" opening.

This amount of clearance permits the rings to contract without the ends coming in contact, causing distortion and subsequent scoring.

To measure ring clearance in groove, see fig. 6. Remove all grit and see if groove walls are straight and not worn. The rings should fit freely into the grooves and should be from .001 to .002 narrower than the groove. See also pages 658, 659.

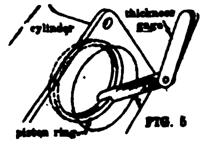


FIG. 5

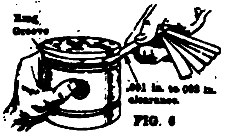
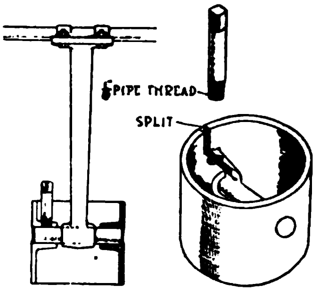


FIG. 6

Miscellaneous.



An expanding cylinder lap, made from a worn out piston. Head of piston is removed. One wrist pin bearing is tapped, then split piston as shown, so that a plug screwed into tap hole will cause piston to expand. An old connecting rod and handle is then provided. Ground glass and oil are used for lapping compound.

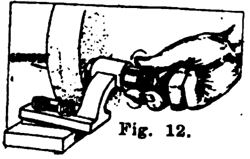


Fig. 12.

Fig. 12. Truing up valve tappets when worn, is shown in illustration.

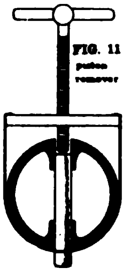


FIG. 11 piston remover

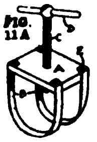


FIG. 11A

Fig. 11. Piston pin remover: A (fig. 11A) is flat iron tapped to take screw C. Flat iron bands are attached so they can be placed around piston, then pressure of screw forced against wrist pin (piston pin), see also page 650.

Fig. 13. Valve tappet guide puller made of short section of 2" iron pipe or any size larger in di. than guide. A washer is then placed over the top of pipe. A bolt which will go through guide hole and two nuts, will complete the puller.

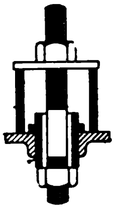
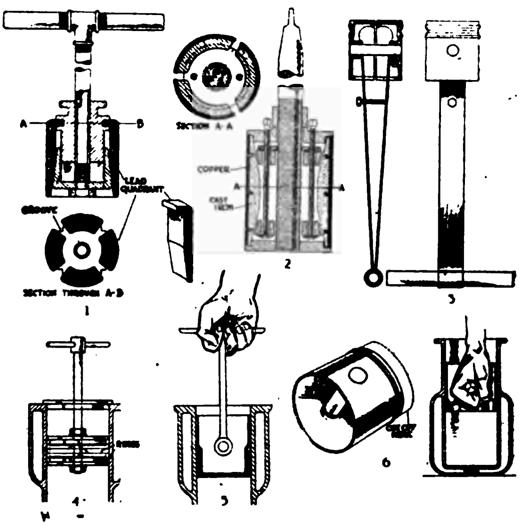


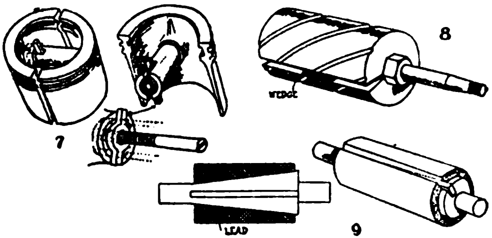
CHART NO. 259-A—Continued from Chart 259. How To Measure Piston and Ring Clearance. Mis cellaneous.

---

*See page 698 for explanation of a micrometer. ****There are three disalignments possible in piston and connectin rod:** Off-set in direction of crankshaft; bend to right or left in direction of crankshaft; a twist in connectin rod—see also pages 659, 646. †See pages 699, 697 for Thickness Gage explanation.



Figs 1 to 6 inclusive showing various tools for lapping pistons and rings



Figs. 7, 8 and 9—Three types of lapping tools

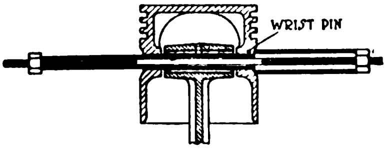


Fig. 22—For removing piston pin or bushings, a rod is turned to slide freely through bushing and then threaded S. A. E. standard. The pulling bushing is made slightly smaller than hole in piston, see also, page 649.

Lapping Tools.

Fig. 2 shows a simple design of an expanding lapper. Such a tool as this may be used in the drill press, an up and down and rotary motion being supplied at the same time. Fig. 1 shows another tool of this type. Its construction is readily understood.

An expanding piston lapper which may be used for lapping rings or cylinders is shown in fig. 3. The two operations should not be simultaneous, however. When the cylinders are slightly scored, the marks should be removed first and then the new rings should be lapped in.

When no piston is available the rings may be lapped between two blocks of wood as shown in fig. 4.

Rings may be placed in an old piston. A new piston should not be used because it will wear away to some extent and this is objectionable. Fig. 5 shows how the lapping is accomplished. Another method is to cut off the head of the piston and use the wristpin for a handle, as shown in fig. 6.

Fig. 7 shows a simple expanding lapper made from an old piston. A piece of tubing is brazed into one piston boss and another tube to fit snugly inside of it is brazed into the other boss. The two halves are kept in line by slotting the two tubes and inserting the member shown at the bottom of the sketch in these slots. Adjustment is obtained by screwing out on the screw as illustrated.

Fig. 8 shows how a cylindrical block of wood, closely fitting the cylinder bore, may be used when an old piston is not available. Emery and oil are put on the cylinders and the lapping proceeds in the ordinary way. Grooves are cut in the surface to aid in the distribution of the abrasive. Adjustment for wear is provided by a slit which is opened by a wedge.

Fig. 9 consists of a tapered arbor over which is placed a lead sleeve; the position of the sleeve determining the exact diameter of the tool. The arbor has a key which prevents slipping. The sleeve is cast in place and then the slot is cut to receive the key. The expansion of the tool is accomplished by driving it further up the arbor. Reduction in size is obtained by moving it in the opposite direction and compressing it.

Lapping Pointers.

If the cylinder surfaces are in good condition only the rings need be lapped. The purpose in lapping the rings is to make them fit tightly against the cylinder surfaces.

The lapping process consists in moving the rings back and forth in the cylinders in the presence of a mixture of ground glass and cylinder oil, or carborundum and cylinder oil.[*] The abrasives should be the finest obtainable. (see page 658.)

When the rings bear all around, the work is finished. This can be seen with naked eye.

If the cylinders are slightly scored they should be lapped with an old piston. It is not desirable to use a new piston because it will be worn away and for the same reason new rings should not be used in the piston during the lapping process.

If cylinders are badly scored an old piston with old rings should be used and after all marks are removed the new rings should be lapped in place, using an old piston.

When the cylinders are badly scored an expanding lapper may be used instead of the old pistons. (see page 649.)

Aluminum pistons cannot be treated in the same way as cast iron because they are too soft. High spots on the pistons may be removed by means of a semi-cylindrical brass lap shown, into which the piston fits.

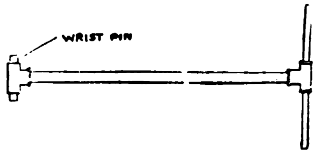


Fig. 20—Another piston lapping handle: When it is desirable to lap a piston of a detachable-head engine without removing the cylinder casting, the tool shown is a time-saver. It is made of ordinary ½-inch pipe, a T at the lower end slipping over the wrist-pin of the piston. The wristpin used in lapping should be made of fibre, as a metal one is likely to score the cylinders. Ground glass and crocus mixed in equal parts is used at the finish and ordinary valve grinding compound at the start.

Removing a Cam Shaft—Dodge as an example.

To remove the camshaft the radiator must be taken off and then the front gearcase cover. The camshaft may then be pulled out after the valve push-rods are tied up so as not to catch the cams as they slide by, and after the camshaft retaining pin (which will be found on the right side of the motor directly back of the ignition unit) has been removed. This pin fits in a deep groove in the center journal. In the first 40,000 or 50,000 cars the pin is held in place by a setscrew, but the newer cars have a spring.

HART NO. 259-B—How to Lap Pistons and Piston Rings.

[*] Another lapping compound for piston, rings, etc., is engine oil or coal oil and flour of emery. For a very fine finish use valve grinding compound secured at supply stores. It is often made of crocus which is finer than emery and is usually used on razor straps.

—Continued from page 645.

lessens the carbon deposit on the piston head and the deposit is more easily removed. In case of extreme heat it is claimed the lynite piston will not "score" or cut the cylinder walls. It is a proven fact, that the lighter the piston the quicker it will operate, therefore greater speed and flexibility is the result.

***The main drawback however, is the "slap"** which often occurs as explained on page 637, unless the pistons fit or the clearance is exact. When cold, the clearance of an aluminum piston is considerably more than cast iron therefore until engine is warmed up there is more or less slapping noise. As the heat increases however, the piston expands and the noise disappears.

The writer knows of one instance where the lower part of an aluminum piston which had a tendency to slap, was grated with a file, like a nut-meg grater, this reduced the noise to a considerable extent, due to the fact that the clearance space was reduced by the roughening process.

**Piston Clearance.

A piston does not fit the cylinder wall tightly, if it did, it would seize and stick when it was heated, as it expands with heat.

The piston rings fit tight however, but being split and of spring tension, they fit the cylinder at all points—or at least they should. For this reason clearance must be allowed between the wall of cylinder and piston, per measurements, page 649.

Cast iron pistons require less clearance than those made of aluminum alloy, because they do not expand so much under the same degree of heat. The piston should fit the cylinder wall with little looseness. Usual practice being to have piston .001 inch smaller than the bore for each inch of piston diameter at the point where the most heat is present—which is at the top.

More clearance is required at the top because here, the heat is greatest therefore greater expansion.

The clearance is usually graduated. If say .005 inch clearance is given at the bottom, the middle would be about .006 and at top say .007.

Q.—What is the clearance of cast iron pistons? For aluminum pistons "lynite etc." For semi-steel pistons?

A.—†**Lynite** .002 in. for each 1 in. diameter at skirt and .004 in. for each 1 inch di. at top of piston.

Cast iron and semi steel require but one half the clearance of lynite. Steel expands slightly more than cast iron.

Above clearance measurements may be reduced to produce quiet running but the danger of seizing will be increased if engine is run at full power or speed for several miles.

If pistons are fit very close to cylinder it will run very quiet but may heat and stick and cause engine to slow down or stop if driven at a high speed. In fact all new engines should be driven at moderate speed for the first 1000 miles—see pages 203, 489.

If pistons are fit moderately loose, they will make noise but will not cause trouble if kept well oiled—regardless of hard work or fast running. The practice is to give greater clearance for higher speed.

Questions Answered on Pistons and Rings.

(Q1) How many rings are generally used on touring car engines?

A—3 or four.

(Q2) How many rings are generally used on racing car engines?

A—1 or 2.

(Q3) What clearance should cast-iron pistons have on an average?

A—.001 per inch of piston diameter at skirt.

(Q4) What clearance should aluminum-alloy pistons have on an average?

A—.002 per inch of piston diameter at skirt.

(Q5) What is the proper method for reboring cylinders?

See pages 653 and 616.

(Q6) What is the difference between concentric and eccentric piston rings?

A—A concentric ring is one of equal thickness throughout its entire circumference. An eccentric ring is not.— At a point opposite the split in ring, it is made slightly thicker, see fig. 6, page 655.

(Q7) Why is an eccentric ring used?

A—**Piston rings are made eccentric in order to maintain a uniform wall pressure on the entire periphery.** Rings of this type are always cut at the thin point. In order that the wall pressure be maintained at the points of a ring of this character it is necessary to compress the material at the inner periphery. This sets up a certain bending moment which would break a concentric ring at a point diametrically opposite the cut. For this reason the ring is weighted up or made eccentric, thereby giving extra material opposite the cut or split part of ring. At the present day, rings of this type are being made in which the scale, due to casting, is left on the inside of the ring and the ring finished on the 3 outer surfaces only.

A concentric ring generally has some other feature embodied which creates the cylinder wall pressure. Some times it is supplied with a spring steel band on the inside, some times by a number of small flat springs, or by circular spring wire. Some times two concentric rings are used, and so fastened to each other so as to have the split diametrically opposite each other. Some advantage is claimed for concentric rings over eccentric rings, for instance, the carbon that accumulates back of the ring will tend to lock an eccentric ring sooner than a concentric ring, thereby preventing the natural shifting of the ring around the piston groove.

---

*See page 638, fig. 7 for Franklin method for remedying aluminum piston slap. The Sterling engine (used on the Scripps-Booth, which has aluminum alloy pistons) has a strip of piano felt placed under the lower piston ring. Manufacturers of aluminum alloy pistons: Butler Mfg. Co., Indianapolis, Ind.; McQuay-Norris Co., St. Louis, Mo.

†Varies with different manufacturers, see also page 649.

†**When aluminum alloy pistons are used** the connecting rod bearings must be fitted slightly looser and clearance between piston and cylinder wall greater —see page 649 how piston clearance is measured.

****The amount of clearance** depends upon the speed of engine, efficiency of cooling system, type of water circulation, length of water jacket. If engine is "hot-running" or heats quickly, clearance is increased proportionately. If "cool-running," give less clearance. It will vary, depending on above conditions—see also page 649 and foot note, page 653.

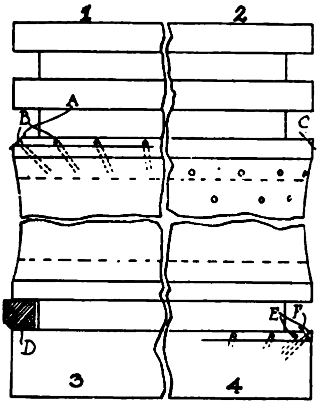


Fig. 6—How to remedy spark-plug fouling from use of too much oil. For convenience the drawing has been divided in quarters to be designated as 1 2, 3 and 4.

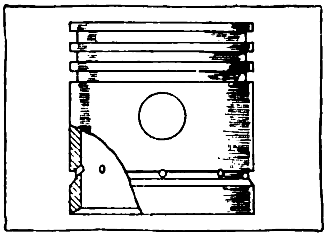


Fig. 8—Another suggestion: To cure excessive lubrication to which some old cars are subject to, the pistons should have a narrow groove turned in the skirt with the lower edge of the groove beveled. With a No. 30 drill about six holes are drilled at equal distances around the piston and at an angle through the groove The sharp edge at the top of the groove acts as a scraper and the surplus oil passes through the drilled holes, returning to the crankcase. No ring is placed in the slot. see chart 286-A, and page 202.

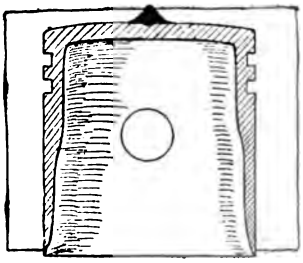


Fig. 9—The collection of carbon on the top of the piston head is often greatly accelerated by the lathe center mark in the head, and where possible this hole should be avoided or filled up. It is the starting point at which the carbon begins to collect and soon there is a mound at this point. The rapidity with which carbon collects can be greatly reduced by smoothing the walls of the combustion chamber, especially the top of the piston. The surfaces should be polished with emery and crocus cloth.

Remedying Excessive Oil with Piston.

At 1 fig. 6, at A,is shown a popular method for overcoming some of the troubles due to an excess of oil. Note the chamfered lower edge of the second ring groove, B; 1-32-inch holes are drilled from the chamfered edge to the inside of the piston. This is for return flow of the excess oil. An extra large hole in each side over the piston pin bearing and running into same will improve its lubrication and insure long life. The number of small holes around the chamfered edge should be determined by the extent of the fouling.

At 2 is shown the chamfered lower edge of the second ring groove and the small holes drilled through piston in the recessed space about the middle. Here, as at 1, the number of holes should be determined by the extent of the fouling.

At 3 is shown the chamfered lower edge of the bottom or oil ring. This very simple method is highly successful, a great deal easier to perform and is the one employed in the repair shops of the various Ford branches.

At 4 is shown the method employed in 1, as applied to the lower ring. Ford pistons before the latter half of 1918 did not have this lower oil ring, therefore the ring wear and travel is limited to the space covered by the three top rings. Since this leaves a space a couple of inches high at the bottom of the cylinder which remains smaller than the top, it will be seen that over-size pistons that will fit the top will not go through the bottom of the cylinders and if it is desired to cut these in it will be found necessary to lap them in. Lapping should be done with an old piston, the rings left in and pinned to keep them turning with the piston. Lapping is best done by power under a drill press with a dummy rod tapered to fit the press. The piston should be rotated and raised and lowered twenty-five to thirty times per minute.

Oversize pistons are not needed where any of the above methods for correction of fouling are used—their only function in such cases being to lessen the noise from piston slap. It is safe to say that a set of cylinders which offer objectionable noise from piston slap have been neglected in the matter of lubrication or are very old in service and in such cases the connecting rod bearings are always out-of-round in direct proportion to the wear of the cylinders and it will be found impossible to keep these rods tight and thus do away with the noise, loose rods occasion. (see also page 202.)

Cause of Smoke and Indications of Color.

If the vapor is black and foul smelling it is caused by too rich a mixture (too much gasoline); this can be remedied in carburetor.

If the smoke is white or blue, the engine is supplied with an excess of oil.

If smoke is gray, there is too much fuel as well as a surplus of oil.

The reason an engine excessively supplied with oil smokes is that if there is too much in the crank case the entire lower portion of connecting rod will dip into it and the lubricant will be forced into the cylinder to work by the rings on the piston, then into the combustion chamber. If there is surplus of oil, more than what is needed, then a remedy is to chamfer and drill holes as shown in fig. 6, and 8 (also page 202) these having a right angled edge at the top side and sloped toward the base, so as to scrape the oil from the walls on the down stroke.

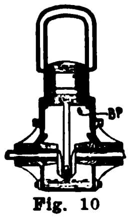


Fig. 10

Another method formerly used was a baffle plate as shown at BP in fig. 10. This is a simple plate of sheet metal in which a slot is cut, through which the connecting rod works, thus preventing an excess amount of oil finding its way into the mouth of the cylinder.

If spark plugs are constantly oil soaked, this indicates leaky piston rings. The oil passes the rings, hence the cause. It can also be caused by the "piston pumping" oil as explained on page 653 and below, even though ring is a good fit.

Vacuum Cause of Piston Pumping Oil.

When you see blue smoke issuing from the exhaust it indicates too much lubricating oil is being consumed.

If this occurs regular at all speeds, it is generally due to piston rings.

If only occurs when engine is run at low speeds for long periods, or idling at the curb, it is due to either cause as follows:

When engine is run fast a vacuum is not produced in the cylinder, because so much gasoline and air is drawn into cylinder.

When engine is throttled down only a little air is allowed to enter, therefore more of a vacuum is produced. The tendency being for the vacuum to suck up oil from crank case past the piston rings.

You no doubt have seen many a car start off from a standstill after the engine has been running slowly for a time and watched clouds of smoke coming from the muffler. Gradually, as the car gets under way the smoke gets less and finally no smoke is evident, unless the mixture should be too rich, in which case the smoke is black.

CHART NO. 260—Piston Relation to Smoke and Excess Oil—Cause of Smoke and Color.

Relation of Piston and Rings to Smoke and Excess Oil.

This subject is treated in chart 260 and below. Note that while rings may be in good condition, yet it is possible to pump oil past them by action of the piston. This is very common on some engines.

*Piston Pumping Oil.

Quite often the combustion chamber will be constantly oil soaked, thereby keeping the plug fouled and cause missing. The front or rear cylinders are prone to this and it appears that it is due to the fact that a necessary amount of oil must be carried in the crank case and when car is going up or down hill the rear or front cylinders get an excessive amount of oil and the piston assists by pumping it past the rings. This is common where there is excessive clearance, especially in old engines and quite often in new ones, where there is excessive clearance to begin with and poor fitting rings in addition.

Another common cause—is too high an oil pressure. It is by no means unusual to see pressures of 30 lbs. employed.

Very few people are aware of the fact that the piston and cylinder walls in a well-designed engine should not be placed in the actual path of the big-end splash.

At ordinary engine speeds the inside of the crank case is in a condition of what can be aptly described as "oil fog," and although all the crankshaft bearings are fed directly with liquid oil, the cylinder itself should be supplied by "fog" only, which is much denser than one might imagine and quite equal to its work in this respect.

Any actual splash which gets on the walls simply leads to waste and carbonization through the oil getting past the rings into the combustion head and being burnt.

Another method adopted by many, is to taper off the top of piston so that the oil instead of gathering on the head will gather in the space around the outside diameter between piston and cylinder walls, where it does the most good.

A third cause of oil waste is to be found in the piston rings.

If worn slightly oval they will cause leakage if their position is not rigidly maintained.

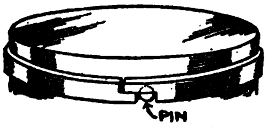


Fig. 8—A pinned piston ring.

It is always advisable, **therefore, to pin them,** and the best way to do this is to drill and tap the center of the ring groove and screw in a fillister headed peg or screw; this head is now filed in half and one of the steps of the ring lengthened to accommodate it. The edge of the step prevents the peg unscrewing, and a very permanent and satisfactory fixture is assured.

Under racing conditions, where the piston is a very slack fit and a minimum of friction essential, a slight advantage in engine speed is obtained by using a surplus of oil, for it is well to explain that in describing these various methods of reducing oil consumption the ideas aimed at are (1) economy and (2) prevention of rapid carbonization. It is not intended to convey that any actual mechanical harm is done to the engine by over-oiling.

Remedy.

Where there is excessive clearance a good plan is to make the ring act as a scraper and beveling off the edge of it's groove as explained on page 652.

The lower and exposed edge of the ring catches the oil during the down stroke, and forces it through the holes back into the crankcase again.

**Cylinder Reboring, Reaming and Grinding.

When an engine runs without oil, the cylinder wall may have become scratched or "scored." (see page 202.)

In fact, cases have been known where cylinder was getting plenty of oil, yet rings being loose, the flame from combustion would work past the loose ring and prevent it from receiving proper lubrication, causing it to heat and cut cylinder.

Cause of a scored cylinder is frequently due to a loose piston pin, which scores, or cuts cylinder wall, thereby permitting a leak between wall of cylinder and ring.

****A scored cylinder can only be remedied by reboring, reaming, or grinding** and this is a job that ought to be done where a special reboring or regrinding machine is installed. When a cylinder is rebored, oversize pistons and rings must be fitted.

****If cylinders are not scored too deep they can be lapped in** with an old piston covered with oil and emery, per pages 650, 649.

The first troubles caused by worn or scored cylinders are fouled spark plugs and excessive carbon deposits due to oil leaking past the piston and rings, compression also escapes by the worn parts, causing loss of power and wasting gas and oil. A very annoying knock or clatter known as "piston slap", soon developes. The longer the engine runs the worse this condition becomes. An engine in this condition is not only wasteful but also very noisy and disagreeable to operate.

†S. A. E. Standards for Oversize Pistons.

There has hitherto existed no uniform practice as to the amount of metal removed in regrinding worn cylinders, with the result that difficulty is experienced in securing new pistons of correct size, from the manufacturers.

---

†The S. A. E. has never adopted any standards for piston clearance because the difference in materials, in cooling, and design of both pistons and cylinders, affect the amount of clearance necessary, see foot note, page 651.

*See also "vacuum cause of piston pumping oil," page 652. ****There is now an electric process of filling up cylinder scores with hard solder alloy,** thus saving time of reboring, etc.

With a view to eliminating all unnecessary expense and delay, the following standards have been accepted by the society and can be obtained from most engine manufacturers.

**10 thousandths inch (.010") large for 1st **
20 thousandths inch (.020") large for 2nd
30 thousandths inch (.030") large for 3rd
40 thousandths inch (.040") large for 4th

‡Questions Sometimes Asked Relative to Reboring, etc.

Q-1—Is there a special hand machine on the market for reboring and regrinding cylinders?

A-1—Yes. They are advertised in different motor papers, see index "Address of Auto Trade Publications." see also chart 247-H and page 529.

Q-2—Can this be done on the lathe?

A-2—Yes by bolting the cylinder to the carriage and use a boring bar; or clutch the cylinder in the lathe and use a grinding attachment.

Q-3—If not, what kind of a machine, and where would I get it?

A-3—There are many makes advertised.

Q-5—What would you advise charging for reboring cylinders?

A-5—$1.00 per inch of bore, that is a 4-inch bore cylinder would be $4.00.

Q-6—Would it be cheaper to order new cylinders from the factory?

A-6—Yes, unless properly equipped. To be properly equipped would not pay unless there was considerable work of the kind.

Q-7—Would it be necessary to have oversize pistons and piston rings?

A-7—Yes. If enlarged. If new cylinders were used the old pistons and rings may or may not be large enough.

Q-8—Where can I get these oversize piston rings?

A-8—From any piston ring manufacturer, or the manufacturers of the engine. Some of the firms supplying pistons, rings etc., are Butler Mfg. Co., Indianapolis, Ind. There are many others mentioned in motor trade papers.

Q-9—I saw in your book about lapping cylininders where they are scored, but not scored deep. You say to lap them with an old piston.

A-9—Yes, use a discarded piston or something of the proper size (see chart 259-B) that will fit when covered with oil and emery or whatever compound you use.

Q-10—Which is best; to grind, ream or re-bore a cylinder?

A-10—There seems to be a difference of opinion on this subject. The following is a statement made by Butler Mfg. Co., Indianapolis Indiana.

"Grinding generates the hole, it does not follow the former bore as a reamer or boring tool. Iron which has seen service and is full of oil is hard to ream or bore, because the tool will not cut as well in the saturated iron, and thus cut deeper on the opposite side. Where the iron is soft the reamer or boring tool will cut deeper than where hard, thus one cannot have a true hole. Reamers press the iron and requires lapping of cylinders to give a satisfactory polished surface. Reamers will not run true in the greater majority of cases, for example examine the cylinders of those who are reaming to-day. The majority are returning to grinding."

"Another condition which you may be interested in has arisen in the construction of engines. This is the condition of the cylinders and pistons as put out by the manufacturer. In this day of rapid production, you will find on careful investigation, the cylinders and pistons in the majority of $500. to $1,500. cars to fit very poorly. The cylinders are reamed and you know the effect of reaming and the experience any one has with a reamer large or small. It is impossible to make a straight and true hole in the majority of cases. We believe this investigation is worth your time and attention. You will find the average car manufacturer and service station attempting to get-by with leak-proof type of rings and claims of other causes for an unsatisfactory engine, but our experience has been the majority of the causes of missing of cylinders, over consumption of gasoline and oil, lack of power and snap, and inability to make proper carburetor adjustments is due to improper fitting of pistons to cylinders and bad cylinders. Please do not understand we are knocking on the engine builder of to-day, we are not. This is simply facts which every one in the game has to contend with. For this reason we regrind the cylinders and grind the pistons individually."

The following is a statement from the Marvel Machinery Co., Minneapolis Minn., (see also chart 247-H):

"Reaming is all right if you are working on a very thick heavy cylinder wall and where you are trying to do the work fast and as economically as it is physically possible. Boring, on the other hand, with the proper tools, can be done perfectly on a very thin cylinder wall. It also leaves the cylinder walls in a much better condition than reaming. Besides, you are able to secure a closer micrometer accuracy by re-boring than you can by any other method of trueing up cylinders."

The Universal Tool Co., Detroit say:

"Our cylinder reboring tool which weighs complete but 60 lbs. will rebore a cylinder from start to finish and will give a perfectly round section as near as is possible in commercial practice within 0.001 in. of roundness, and capable of taking as much as 1-16 in. oversize in one operation."

Q.—What is the extreme amount of metal which can be removed from cylinder in grinding or reboring?

A—Varies from .020 to .125 in. Dependant on the original thickness of metal comprising the cyl. walls when made. Just as little as possible to insure roundness.

*Piston Rings.

A piston must be fitted with piston rings. The piston itself is slightly smaller than the bore of the cylinder in order that it may move up and down easily. The rings are fitted in grooves as shown in figs. 4 and 6, page 74. See also page 649.

There are usually three rings to a piston which are fitted above the wrist pin, sometimes there are four rings, one placed below the wrist pin center. (see fig. 6, page 650.)

A concentric and eccentric ring is explained on page 651.

The grooves in which the rings fit are slightly larger than the ring, in order that the ring may have room for expansion. If the groove is too large, the compression will leak between the groove and the ring.

---

*See foot note bottom of page 655 for size of piston rings used on leading cars.

****The meaning of 1st, 2nd, 3rd and 4th is this;** if cyl. is scored or cut, say .009 inch deep, then bore it to fit a .010 inch oversize piston. If cut .011, then bore it for a piston .020 inch—but not between the two. In other words quite a number of auto manufacturers furnish pistons larger than their standard product by increments of .010 inch, thus making it possible to regrind scored or worn cylinders to these S. A. E. standards and procure pistons from stock.

‡**A re-boring attachment** can be secured of the South Bend Lathe Works for use on South Bend Lathes of 16 inch and larger size. A circular descriptive of this attachment can be secured by writing to the South Bend Lathe Works, South Bend, Indiana—if you mention this book.

The expansion of piston rings is very necessary. If the expansion is not equal at every point of the circumference the gas will blow by the uneven space.

To permit the ring to expand, a gap or joint is provided as shown in figs. 5 and 6.

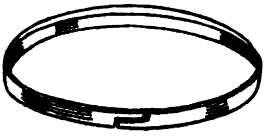


Fig. 5—Step cut piston ring with stepped or lapped joint which prevents leakage of pressure at the joint.

Note eccentric shape of ring. If concentric it would be same thickness all the way around.

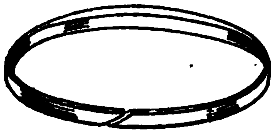


Fig. 6—Mitre cut piston ring with a short beveled joint. (Note the long bevel joint on the Inland—opposite.) Easier to make than the Inland type, but not quite so effective in preventing possible leakage.

Piston rings working around in the groove: It is not an unusual experience to find a set of piston rings possessing a peculiar weakness for working around the grooves till the slits arrange themselves more or less in line.

It is a common belief that if the joints come in line an escape of explosion pressure from the combustion chamber to crank case is bound to occur. This is not always necessarily the case. It must be remembered that if the rings are made the correct size, the ends should close up, certainly to within 1-64 of an inch, when the ring is in the cylinder. There is not, however, much of a passage for an escape of gas; and then there are also the walls between the other grooves interposing between the joints.

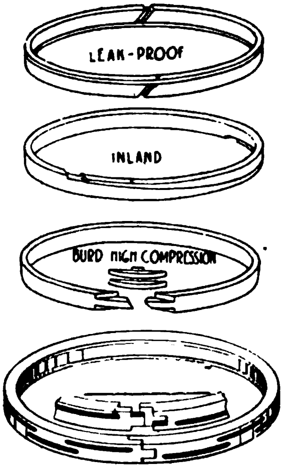
If the ends of the rings do not meet, then a leakage of some consequence may occur. The piston itself does not make as close contact with the cylinder bore as the rings; hence if there is an appreciable width of slit existing in each ring, it is not difficult to see that some of the high pressure gas might worm its way into the crank case. It is rather a puzzle why the rings should move round at all. One theory is that the explosion communicates a very minute (almost imperceptible) rotative movement to the ring, and a slight escape occurs to the others, and so on, the path of escape tending to shorten itself.

Pinning the ring with small pins about 120 degrees apart, and then very carefully notching the ends of the rings with a very small round file, so that the semi-circular notches just close over the pins is one method for preventing the rings working around in its groove. (see fig. 3, page 653.)

Care should be taken that the pins are screwed tightly into the piston and do not stick out as far as the surface of the rings, otherwise they will be very liable to damage the cylinder.

†Improved Rings.

Since the advent of the patented ring, pinning is not necessary as it is claimed the gas cannot pass this ring at the joint or elsewhere. The illustration shows four popular patented rings; one called the Leak Proof, another the Inland another called the Burd High Compression and another called the Harward. There are many others.



The Leak Proof is of two parts, whereas the Inland is made of one piece with a long joint.‡

There is one point to consider however, in using rings of this kind. They may prevent lubrication from reaching the uppermost part of cylinder and result in a scored cylinder wall. Therefore it is sometimes advisable to first try one ring of the gas tight style and place it at the top and then see if the results are satisfactory. See if compression is satisfactory and if an excess of oil passes—providing this was the trouble before fitting the rings.

Newly fitted rings also require careful running and plenty of oil until worn in.

Piston Ring Leaks; Cause and Effect.

If the rings are not equal in expansion on all of its surface and does not fit true to the cylinder, the result will be loss of compression, hence a loss of power. Another result will be a smoky exhaust as explained on page 202 and 652.

Under the head of "Compression" the various causes for leaks were enumerated.

Leaky piston rings cause the loss of compression by permitting the compressed gas in the head of cylinder to pass between the walls of the cylinder and rings.

If the rings are in good condition they will be smooth and shiny, as will also be the cylinder walls.

If the rings are dull and dirty in spots and streaks, it will indicate that the flame from the combustion passes between the rings and cylinder wall, leaving a sooty deposit, as will also the compression pass, reducing the power of engine.

---

*Size of piston rings used on Leading Cars can be determined by referring to the bore of the different engines under "Specifications of Leading Cars" (charts 229 to 284). Those sizes used most should be carried in stock. Charts 247A and 247BB. ‡See advertisement.

†See page 609. A late model ring made by the McQuay Norris Co., St. Louis, mnfg'r of the "Leak-Proof" ring, is called the "Superoyl" ring. A small oil groove or reservoir is cut around the lower edge of ring. It is intended to be installed in the top groove of each piston. It is a concentric ring with an oil reservoir cut into it at an angle of 45 degrees from the intersection of the cylinder wall and the lower groove bearing face of the ring, thus providing a scraping edge.

Causes of Leaky Piston Rings.

(1) Rings **sticking in their grooves** because of gummy deposit from lubricating oil; rings that are stuck in their grooves will usually not press against the cylinder walls, (2) rings may have become **broken**, (3) the joints of the rings **may be in line** allowing the compression to escape, (4) rings may be **worn or cut** from lack of oil, (5) rings may **not be wide enough** for the grooves, (6) the oil pressure may be **too** great and oil of **too thin** a body used.

Testing Piston Rings and Cylinder for Leaks.

In order to find out if the rings leak, try the piston and see if the gas is escaping through the rings into the crank case. This can best be accomplished by removing the lower part of crank case, after which turn the crank so that the piston makes its compression stroke, and listen for a bubbling sort of hiss in the crank case. Test each cylinder separately by opening the relief cocks in the cylinders not being tested. First determine which cylinder it is that is leaking. There is no mistaking this sound, since the crank chamber acts as a resonator, and even the slightest leakage is distinctly audible (also see page 629).

If the sound of gas escaping past the piston continues for an appreciable time (upward of a minute or so) the chances are that the use of an oil of slightly heavier "body," for cylinder lubrication, will cure the fault.

However, if the escape is of short duration, the matter is more serious, involving as it may a cracked piston, scored cylinder walls, or broken, warped or gummed rings.

If this is suspected, flush out the cylinder combustion chamber with an oil-gunful of gasoline, making no attempt to fully remove the liquid. Again put the piston on lower dead center, and with the aid of an electric lamp and a small mirror, observe the bubbles caused by the escape of the gas about the lower edge of the piston. There will naturally be no bubbles at this point, if the piston head is fractured, but it may be possible to see the crack through which the leakage occurs. At any rate, if enough gasoline has been left in the cylinder, one will be able to see it trickling down the connecting rod or inner piston walls, should such a crack exist.

If the cylinder walls are scored, one will see the liquid at but few points about the lower edge of the piston, and, as the gasoline washes the oil away, possibly the score marks also will be seen.

In case the trouble is with the rings, the bubbles will be more evenly distributed about the periphery of the piston and will be all of about the same size. Should this latter be the condition, the use of a kerosene injection (about an ounce each night after running the car into a garage) for a few nights will in all probability, eliminate the leak if the rings are only gummed. If this latter is not effective, the job is one of replacing rings.

If the gas is escaping through the rings, then it will be necesary to take out the pistons and look at the rings. If there is a black spot on the rings, it is evident that the gas has been escaping at this point.

Remedying Piston Ring Troubles.

Gummed rings: After long periods of running, a deposit of charred, or partially charred lubricating oil is liable to form behind the ring and interfere with its free movement; it is a good plan, therefore, when overhauling the engine to slip off the rings from the piston and thoroughly clean out the grooves.

A kerosene oil treatment to loosen rings: I have known engines to lack power from merely the rings becoming gummed up. This trouble can be remedied by first running the engine until it is warm, then stop, take out the spark plugs, fill each cylinder full of kerosene by pouring the kerosene through the spark plug holes.

Plug up the holes with old spark plugs and then crank the engine several times by hand so that the oil will work its way down around the rings; leave this oil in over night and next morning crank the engine quite a number of times until you think the oil has passed into the crank case. Drain the crank case. After draining and putting in fresh lubricating oil, start the engine. The engine will smoke considerably to begin with, but this will soon pass away. This will not only loosen up the rings, but will also clean any carbon that may have become deposited in the combustion chamber. This treatment oftentimes saves the trouble of fitting new rings, and in some instances will make a marked difference in the running of the engine. (see page 201).

If the ring is broken or it is dull and dirty in spots and streaks (see page 655), then a new ring or rings must be fitted.

If ring is cut or scratched, a new ring is necessary.

If walls of cylinder are cut or scratched, then rebore, grind or ream, as per page 652, and fit oversize rings as per page 609.

If the ring has lost its tension and does not spring freely against the walls of the cylinder, then it must be treated as shown in fig. 3, page 657.

Remedying Excessive Smoke.

As previously stated, if the rings are leaking, an excess of smoke will pass out the exhaust, caused by oil passing the rings and entering the combustion chamber. see pages 202 and 653.

Removal of Rings.

The removal of rings from piston grooves is not difficult if a little forethought is taken: to open them it is best to use a pair of very thin jawed pliers, the jaws opening outward, (see fig. 11) a substitute for pliers can be made from iron wire.

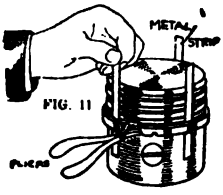


FIG. 11

When the ring is slightly expanded by the use of special pliers, similar to those shown in fig. 9, page 659, a narrow slip of very thin metal, (tin or brass will do) should be pushed through the opening and worked to the opposite side of the slot; then if the ring is opened a trifle more, an additional slip of metal can be placed near the ends of the ring, when it can be worked off quite easily and without any risk of breaking it, such as an attempt to expand it larger than the piston diameter would do.

It is a good plan to mark each ring for its own groove, and also when they are not pinned, to mark just where the slots should come on the piston. (see chart 261.)

Poening Piston Rings.

This operation is for a ring which has lost its tension. A poening hammer should be used instead of the various flat-headed types that are used at times for poening a piston ring. The metal may be more readily distributed by the blows from a poening hammer, which can be directed better, since the head is so designed that a large part of the surface is not covered at one time nor struck by any single blow. In this manner slight changes in the shape of the metal may be made without distorting the metal in any way. It is very important in any poening operation that the surface upon which the hammering is done be as flat and hard as possible, for any irregularities in the shape of the surface plate will be just as effective in causing distortions as a blow from a badly shaped hammer. A good method of providing such a surface plate is shown in fig. 3.

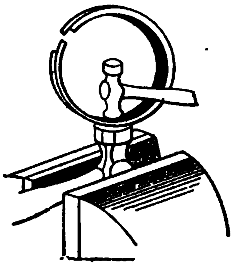


Fig. 3—Poening a piston ring.

*Fitting Ring to Cylinder.

†**After having selected a set of rings, the first operation is to fit them into the cylinder.** Taking one of the rings, try very carefully to shove it straight in, concentric with the cylinder walls; if the ring is of the diagonal slot type (fig. 6, page 655) and its diameter a little large, the ends will run upon each other, throwing the edges out of line; while if a ring with step-cut overlapping ends is used, such as is to be found in some engines, it will not go in at all, therefore ring ends must be filed.

A very simple and effective means of holding a ring for filing is shown in fig. 1. The ring is placed on a block of wood and a few small nails driven into the block both inside and outside of the ring in such a manner that the ring is held securely in place for filing. The heads of the nails are then cut off, the ring removed, and the nails filed down so that they will extend just below the top surface of the ring when it is replaced on the block. With the nails well placed, there will be no danger whatever of breaking the ring when filing. A thin, smooth, flat file is best for this.

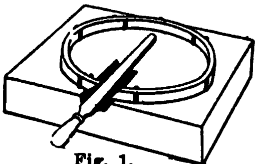


Fig. 1.

The ends must be trimmed off so that when the ring is well up into the cylinder there will be a space about .004", per inch of cylinder di., between ends, per fig. 5, page 649, to allow for expansion caused by heat of the explosions. The groove on the block shown in fig. 1 is used when reducing the diameter of diagonally-slotted rings.

Try each ring in the cylinder, being sure to have it placed about ½ inch from the bottom all the way around, then measure the opening in the ring. Piston rings should have not more than 1-64 in. opening to have a good fit. If it is more than this, compression can easily escape.†

The ring should be repeatedly tried in the cylinder in order that the space is not filed to exceed the dimensions stated. The inside portions of the rings near the ends should rest against the nails in order that they may not be broken off when filing the slot. Having attained the proper space between the ends of the ring, now place a light in the cylinder behind it and see how its face conforms to the wall of the cylinder.

Testing a Ring to Cylinder.

To work or lap a ring to fit cylinder: make a plug of yellow pine (fig. 4) to fit easy into the cylinder and square one end. Lay the ring on this end with a small batten across, secured by a screw through the center, but not holding the ring tightly. Smear the bore as evenly as possible with a little vermilion and lubricating oil mixed to a paste, and move the ring to and fro in the cylinder while held square by the plug. Generally, it will be found to bear hardest at each side of the slot. File such places carefully with a smooth file.

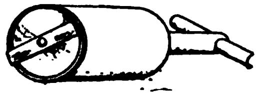


Fig. 4—A handy device for testing and fitting the piston rings in cylinder. This device consists of a round block of wood with handle on one end. The piston ring is placed on the other end and is placed in the cylinder and worked back and forth.

***To renew rings requires no particular skill.** They are usually allowed to run themselves in. It is better however, to lap them in, as explained on pages 650, 649. The regular piston should never be used for lapping rings. †See also, page 649, fig. 5, for ring opening clearance.

If one part of the ring fits and another part does not, the high spot shows up when the ring is dipped in gasoline and then rubbed with cloth. The high spot will be more shiny than the rest.

When the ring fits well all around, the overlap of the ends should be absorbed; if not, file them until the edges have about 1-64 clearance when the ring is in the cylinder.

If the ends of the rings be hard butted against one another when in place in the cylinder they may be buckled by expansion when hot, and make starting a two-man job; therefore, file them as shown in fig. 1, page 657 and be sure there is a clearance.

If there is a contact all around, when testing rings in the cylinder, the ring is then ready to be fitted to the piston; but if the contact is poor, either the ring or the cylinder is out of round, leaving space between cylinder wall and the ring, as at C and P in figs. 2 and 2C. If the fault lies in the ring, the face can probably be dressed down to fit, or another selected; but if the cylinder is badly out of round, it will have to be rebored or reground, or both, as the case may be, or (in extreme cases) replaced with a new cylinder.

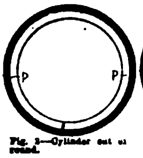


Fig. 2—Cylinder out of round.

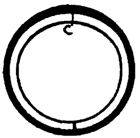


Fig. 2C—A sprung piston ring, see C. This shows that the ring was sprung in putting it on the piston.

*Fitting Rings to Piston.

†**When the rings have been fitted to the cylinder, the next operation is to fit them in their respective grooves on the piston.** As regards the fit of the rings in the grooves, they should be just a free fit, neither tight enough to jam, nor slack enough to rock.

Tight rings may be eased by grinding or lapping the edges on a sheet of fine emery or crocus cloth, fastened to a piece of board planed quite flat. The ring is gently rubbed backward and forward with a downward pressure. (see fig. 3.)

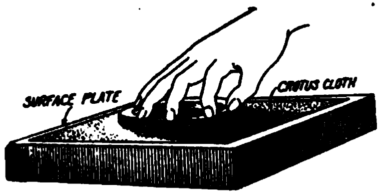


Fig. 3—Method of dressing or lapping piston ring to fit the groove in piston on a surface plate.

***Lapping** should not continue for a long period on one side. The ring should be turned over occasionally. After lapping, the ring should be immersed in clean gasoline and fitted to the groove. Not any groove, but the groove which it nearly fitted before. If every part of the circumference of the ring fits every part of the groove then lapping is complete and the ring may be tagged to designate its location. 1-1 on a tag is made usually to represent first cylinder, ring number 1. Ring 1 is that nearest the top of the piston.

To properly dress down a ring requires some skill, and a good mechanic will select a ring which will demand the least amount of trimming, for it is a delicate operation.

Most manufacturers now cut the grooves in the piston, and grind the face and edges of the rings to a gauge, making very little hand-fitting necessary. But there are cases, (and these are the ones that generally come into the repair shop) where the cut was just a trifle larger, or the ring a little smaller than the gauge, making it essential that each ring be individually fitted to the groove in which it shall subsequently rest.

When fitting rings in the grooves, begin with the ring selected for the bottom groove, so that ring will be the first to be slipped onto the piston. First try the ring without slipping it over the piston by inserting it in the groove and rolling it around its circumference, to see if groove is deep enough and wide enough at all points.†

It should fit snugly, as at A, fig. 2-A, but still be free to slide in and out easily; if it binds in any place, apply a thin film of red or black lead or Prussian blue in the same manner as used in scraping bearings, to locate the high places, then dress down with a smooth, flat file and try again. **When filing is necessary, it should be confined to one edge in order that at least one good edge is retained, for it is almost impossible to secure as regular a surface with a file as that made by a grinding machine or on a surface plate.**

An example of ill-fitting rings is shown at B. fig. 2B, and in fig. 2C above. The space C shows that the ring was sprung in putting it on the piston.

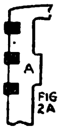


FIG 2A

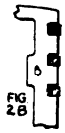


FIG 2B

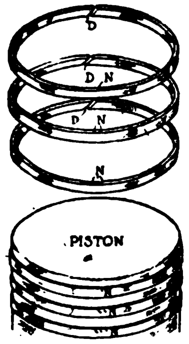
Having fitted one ring, put it in place immediately and repeat the operations with the next ring. See fig. 12, page 659 for slipping rings in grooves.

After fitting new rings engine will require considerable running with plenty of good oil to properly work them in, before the engine will give its proper power. See also pages 793, 203, 507, 589, 643.

***When fitting patented rings** remember, if the rings are absolutely tight they might prevent lubrication altogether and cylinder would run dry. Therefore many place merely one patented ring in the top groove and the regular rings in the other grooves.

The patented type of ring requires very little lapping by hand. When put in the cylinder, the engine is allowed to run by belt a few hours, you will find that that is all the lapping that is necessary, unless of course, the cylinder is scored or badly out of round. In such cases, the proper remedy is to have the cylinder rebored, and new oversize pistons made and piston rings made to fit the new diameter of the cylinder.

†See also, page 649.



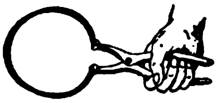


Fig. 9—Piston ring plier

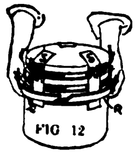


FIG 12

Marking Piston Rings When Removing.

The amateur or junior repairman who removes the piston rings from a piston for the first time; either for examining the piston-ring slots for sand-holes or wear, or for cleaning the rings and slots, generally neglects to see that the rings are marked so that they may be replaced in their proper grooves. The result is that considerable difficulty often is experienced in getting the rings back into the piston in good order. To avoid this, one foreign manufacturer of motor cars, marks the piston rings as indicated.

The ring in the top groove of a piston has one notch N in the upper, inner edge, opposite the diagonal (D) where the ring is thickest. This notch is made with a file and is very small, so as to be just visible, but at the same time not deep enough to weaken the ring. In a similar manner, the next ring below it is marked with two notches and the third ring, with three notches. If more rings are used a corresponding number of notches are employed to mark them. **With rings thus marked** there should be no difficulty in getting rings replaced in their proper grooves. Care should be taken, however, when the rings from more than one piston be removed at the same time. In fact, it is advisable, to remove, clean and replace the rings of one piston, before removing the others.

Fitting Rings to Grooves of Pistons.

Fig. 12—A quick and safe method of slipping rings into the grooves is shown in fig. 12. Take three strips of sheet metal, brass or tin (S), for instance, about 1/32 inch thick, ½ inch wide and 5 inches long; bend these at right angles and hang them on the edge of the piston at equal distances apart. The ring (R) may then be slipped over these skids till it is opposite its groove, when the strips may be removed and the ring allowed to slide into place. Install ring in lower groove first and work to top groove last. The same strips may also be successfully used in removing the rings. (See page 649, how to measure ring clearance.)

When fitting rings place the best fitting ring at top, so that oil below it cannot be consumed by the high temperature of the exploding gas. If fire flows past the rings into the crank case, oil will be burnt off of the piston and cylinder wall, causing it to become scored even though your oiling system might be working perfectly with the best grade of oil.

When placing the rings on the piston ready to replace the cylinders they should be set with the joints (if it is a piston with three rings) about one-third way from each other, so that the openings will not come in a straight line or be close together.

Replacing Piston in Cylinder.

Before putting pistons into cylinders, oil (cyl. oil) inside of cylinder and inside of piston as oil will not have a chance to reach upper portion when first **starting.**

When replacing piston in cylinder, some device must be provided for holding each ring in its groove so it will easily enter the cylinder. **A string may be used** to advantage, as shown in fig. 10. A better method however, is shown in **fig.** 8.

Replacing cylinders over pistons: It is not difficult to put a single cylinder back on its piston after it has been necessary to take it out, but it is not so easy when the cylinders are cast in pairs, as it is difficult to **guide the rings** into the cylinder barrels simultaneously. The job is greatly simplified by **taking** the precaution to place the cranks up and down, so that one piston is at its highest point and the other is at its lowest. This means that the pair of cylinders can be dropped straight over the pistons, the rings of the upper piston being **guided** into the cylinder before those of the lower piston are replaced. When it comes to dropping one of the mono-block castings of four cylinders on to four pistons, it is still best to work this way, so that only one other pair of hands are required and that the two upper pistons may be guided into their cylinders first and then the two lower ones.

Note: When reinstalling a piston be careful not to push it up into the cylinder as far as it will go, the upper ring may jump over the valve opening, holding the piston until the ring is released which is a difficult task to remedy.

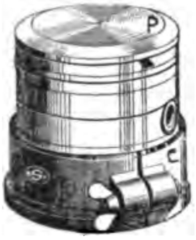


Fig. 8—A serviceable device (C) for compressing rings when fitting piston (P) to cylinder. Especially adapted for Ford pistons which are not champfered.

This tool is bored with a long gradual taper which allows the open rings to enter easily at the top. It is placed in position over the cylinder, and as the piston is forced downward into place, the rings are gradually compressed sufficiently to enter the cylinder.

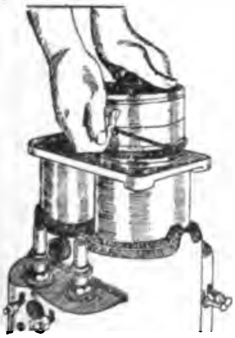


Fig. 10—Method of replacing a piston in the cylinder with a string holding the ring in its groove.

Don't Bend Connecting Rods When Replacing Cylinders.

Incidentally, it would be well to note that many times knocks that develope in engines (after same have apparently been thoroughly overhauled), is often due to the fact that the connecting rods are slightly bent sidewise, **out of true in fitting cylinders down over the piston.** One cylinder will get a slight lead, or one ring does not properly enter, cylinders are twisted and in an effort to align them, rods are bent. When engine is finally assembled it is very noisy, due entirely to the fact that one or more of the rods have been bent sidewise, and when the force of the explosion is exerted on the piston head, the wrist pin end of the connecting rod is driven side-wise against the piston boss. See foot note bottom of page 649.

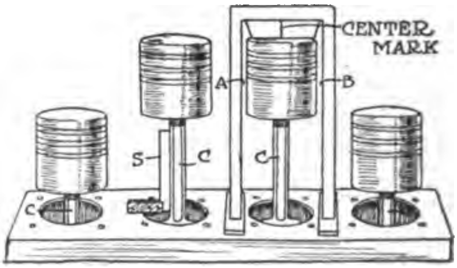


Fig. 3—One method of lining up pistons and connecting rods of block type engines. S represents a square placed alongside the connecting rod C to determine whether it is true or not. (see also page 649.)

To test its alignment, place the U frame over it as shown, so that center of piston is in line with center mark on cross member. When distances A and B are equal, piston is true and square. See also page 646, figs. 1 and 11 and foot note page 649.

CHART NO. 261—Marking Piston Rings. Lining Up Pistons and Connecting Rods. Applianc for Removal and Replacement of Rings. See page 649; how to measure piston and ring clearance.

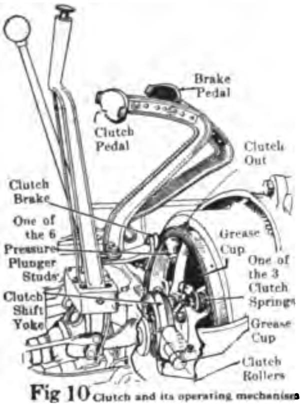


Fig 10 Clutch and its operating mechanism

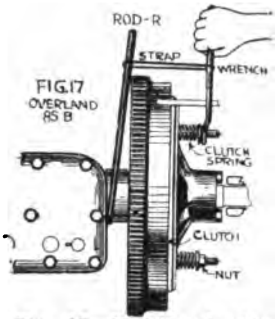


Fig. 17—Method of compressing clutch spring to remove or replace nut—see also fig. 8, page 647.

Cone Clutch Adjustments.

The adjustments are with clutch springs (fig. 10), which tend to **keep** the clutch engaged. While it is possible to adjust these **springs to** avoid shifting, the tension should be as little as possible. **Tightening** the springs too much will not only make clutch hard to disengage, **but** will tend to make the clutch "grab." **Adjustment is made by increasing or decreasing the spring tension of the three clutch operating springs,** by advancing or backing off the nuts on clutch springs. (On some clutches spring is on the clutch shaft per fig. 2, pages 664 and 665.)

The clutch pressure or plunger studs (fig. 10) consist of six **small** spring mounted clutch plungers placed under clutch leather, which **raise** it at various points and allow gradual engagement of the friction surfaces. Should these plungers become fast in their guides, or should anything prevent the leather over these plungers from first coming into contact with the seat in the fly-wheel before the entire surface **engages,** "grabbing" will result. They should be **adjusted so that with clutch** in complete engagement approximately ⅛" remains between the **adjusting** nut of the plunger stud and guide to cone.

Clutch rollers (fig. 10), which by pressure upon **clutch shifter yoke** disengage the clutch from fly wheel should be kept well greased—**see also** fig. 19, page 666.

Ball thrust bearings (fig. 16, page 661), should be supplied **with oil** by placing oil can spout through spokes of clutch drum.

Clutch brake—is for the purpose of keeping the clutch from **spinning** when thrown out. See fig. 10, it consists of a small spring mounted **fibre** pad attached to left of frame, against which the clutch cone **strikes when** disengaged. It should be so adjusted that when pedal is **pressed** half way down the cone should just begin to come in **contact with it, so** that by time pedal is all way down, the spring on clutch **brake will be** fully compressed.

To remove or replace clutch spider or cone; see fig. 17—**the three clutch** springs are very powerful. A simple method of compressing the **springs** so that the nuts can be put on or taken off is explained in **illustration**—see also figs. 1 and 2, page 664 and page 665.

Before clutch can be removed, it will be necessary to remove the universal joint and parts adjoining the clutch.

Fitting New Leather To Cone Clutch.

First be sure that replacement is necessary. See pages 661 and 662 and note the causes of trouble.

If leather is worn or rivets project, then it will be necessary to remove clutch to either **replace** leather or drive rivets down below the surface of the leather.

If a shoulder of about 1/16 or 1/32" has worn **on** leather, then by carefully trimming it off with a file or rasp will permit cone to go further into fly wheel and may be all that is **necessary—together** with cleaning the whole surface of leather and removing oil or glaze and then applying Neats foot or castor oil dressing.

* **If however a new leather is necessary then procure it of the dealer of the car if possible. It comes cemented ready to apply** and can be slipped over cone and driven into position with a mallet or piece of wood.

If you must make the leather facing, then first remove the old leather by cutting the rivets with a chisel and hammer. Then procure first class unstretchable leather belting (or chrome tanned leather) 3/16" thick for the new leather.

The leather should be first cut as shown in fig. 8.

Then place the leather over the clutch cone in the correct position and draw it as tight as possible. The leather, if cut as shown, will lap from 3 to 4".

Mark on the inner side of the lapped leather the end of the first turn which lies against the cone. Next remove the leather and measure back or toward the long end of the leather ⅝ of an inch. Measure back from the unmarked end of the clutch leather 3" and bevel the leather off as shown in the illustration. Add 3" to the corrected length of the leather and bevel this end as shown.

The leather may now be cemented and after it is thoroughly dried may be installed. Always put rough or flesh side on outside.

For the kind of cement to use, ask a harness maker.

Before a new clutch leather is installed, it should be thoroughly soaked in Neat's foot oil and stretched tightly over the clutch face. Before the leather is fastened to the clutch drum, the "clutch plungers" (or pressure studs) should be forced in below the surface of the clutch cone and held in this position by the clutch plunger adjusting nuts which may be screwed up on the stem of the plunger.

In riveting the leather on to the cone, extreme care should be exercised to see that the rivets are properly clinched or turned over on the inside of the clutch cone and that the heads are driven into the leather of the clutch face until they are well below the surface. Unless this is carefully done, the clutch will "grab" or engage suddenly with consequent disastrous results. (see also page 664 fitting clutch leather to **Chevrolet** cone clutch.)

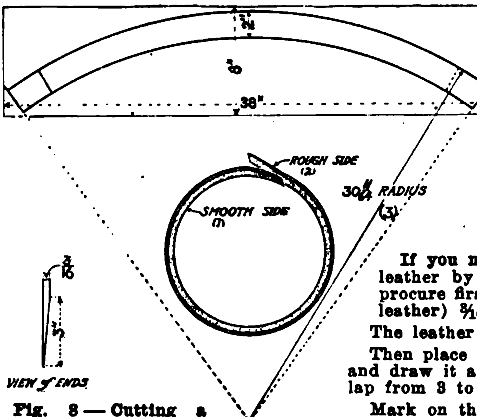


Fig. 8 — Cutting a clutch leather for the Overland roadster clutch,

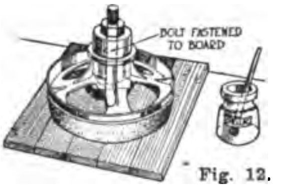


Fig. 12.

Fig. 12—A suggested method of forcing a new clutch facing on a cone by drawing cone into it by a bolt as shown. A small amount of shellac is applied to the clutch and allowed to set before the stud nut is loosened. After this leather pegs are used to complete the bond between leather and clutch. (Motor.)

CHART NO. 262—Cone Clutch Adjustments. Fitting a Cone Clutch Leather. Overland Roadster as an Example—see fig. 4, page 647 and fig. 19, page 666 for Overland 75B.

---

*An alternative sometimes used for older makes of various cars—is "raybestos" strips as used for **brake lining.** It is made in parallel lengths and riveted to cone in six or eight sections, the edges being cut at a **slight angle** according to the diameter of cone.

INSTRUCTION No. 46-A.

REPAIRING AND ADJUSTING CLUTCHES, TRANSMISSIONS AND AXLES: Cone and Disk Clutches. Removing Wheels and Shafts from Rear Axles. The Differential.

*Cone Clutch Repairs.

Clutch—How to Use Properly.

The clutch on an automobile should be either in or out absolutely.

Many good drivers make it a plan to keep their foot off the clutch pedal while they are driving. The weight of the foot on the pedal and a little nervous tension in the driver's leg is sometimes just sufficient to hold the clutch out just far enough to "slip it" on a hard or sudden pull.

Another good way to spoil a clutch is to throw it out in traffic until the car comes almost to a standstill—then to speed up the engine and slip the clutch in with the gear shift lever still in high speed.

When the car slows down with the clutch out, the gear lever should be slipped to second speed and if the car comes to a full stop, to low speed.

Another important point in driving is to learn to engage the clutch gradually and not to "bang" it in with the engine racing.

It is always better to run on the engine as much as possible, throttling it down instead of constantly throwing "out" the clutch.

A well adjusted clutch takes hold gradually, does not slip after it has come to a seat, and releases instantly when the pedal is depressed.

Parts of a Cone Clutch.

Cone; leather facing over cone; ***clutch springs** which hold the tension of cone to fly wheel; **pressure or plunger studs** which are spring mounted and placed under clutch leather at various points and allow gradual engagement of frictional surfaces. The "grabbing" feature is eliminated by the use of these plungers, usually six, inserted under the leather as in fig. 4, page 666 and fig. 10, 660; **clutch rollers** on the shifter yoke; **ball thrust bearings** on clutch shaft; **clutch brake** which prevents spinning of clutch—see fig. 10, page 660 and fig. 16, below.

Cone Clutch Troubles

Cone clutch troubles are either fierce engagement or grabbing, slipping or spinning. The latter trouble makes it difficult to shift the gears of the transmission.

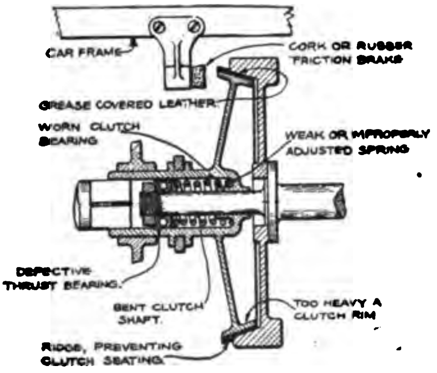

CAR FRAME
CORK OR RUBBER FRICTION BRAKE
GREASE COVERED LEATHER
WORN CLUTCH BEARING
WEAK OR IMPROPERLY ADJUSTED SPRING
DEFECTIVE THRUST BEARING.
BENT CLUTCH SHAFT.
TOO HEAVY A CLUTCH RIM
RIDGE, PREVENTING CLUTCH SEATING.

Fig. 16. Various cone clutch troubles illustrated. (from Motor.)

Cause of Clutch Grabbing.

Clutch leather dry or hard. This can be remedied by applying neats foot or castor oil by first cleaning leather with kerosene using an oil gun to remove any mineral oil.

Clutch rivets projecting, due to wear of leather. Remedy by placing a center punch against rivets and hammer until below surface of leather. A grating or grinding sound will indicate this trouble.

Clutch lever linkages out of adjustment. The amount of movement between the surfaces of clutch is small and it is important that no looseness exists in the pedal connections.

Excessive tension on spring clutch—if excessive weaken the spring tension. Excessive tension also causes undue strain on the ball thrust bearings.

Plunger studs improperly adjusted—the six small studs, fig. 10, page 660 should be properly adjusted—see page 660 and fig. 4, page 647.

Clutch rollers may be worn, due to lack of lubrication. If run dry they are liable to seize and prevent clutch release entirely in which case new rollers must be fitted—see page 660 and fig. 19, page 666.

Cause of Clutch Slipping.

Burned or worn clutch lining—usually resulting from allowing clutch to slip when starting, speed changing and using clutch too much, instead of throttle while running. Even though worn to a certain extent Neats foot or castor oil will sometimes improve its operation. Otherwise a new clutch leather must be fitted.

Clutch leather oily and greasy—the cure is to either wash the oil off by spraying a pint or so of kerosene with an oil gun, over the clutch leather, while holding the clutch out, or wiped off with a cloth moistened with kerosene and then dress leather afterwards with Neats foot oil. The oil can also be absorbed by using powdered Fullers earth or talc sprinkled over the surface and leave standing for a while. Don't use dirt or sand—it will cut the leather.

---

*The clutch spring can be arranged as shown in fig. 10, page 660, or as fig. 16 above. and fig. 2, page 665. See also pages 38, 647, 666 for cone clutch explanations and adjustments.
See also pages 543 to 545 for type of clutches used on different cars.

Leather worn down—if it cannot be raised enough by adjustment of the plungers, fig. 10, page 660, then a new leather must be fitted.

When the surface of the clutch and seat are new, they touch all over, but when worn, they touch on only the high places. If the surfaces touch in only a few places, they naturally cannot transmit the power that is possible with a good contact; they can be forced to transmit it by pressing them more firmly together, but it is better to reface the surfaces.

Clutch spring tension weak—tighten adjustment, see page 660. If no adjustment nut on spring, place a washer between spring and its seat. **Also examine the pressure or plunger studs,** fig. 10, page 660.

Clutch shift out of line—sometimes caused by two great a spring tension causing balls to break in thrust bearing and cutting ball race, lowering the clutch shaft out of line. Also may be due to a bent clutch shaft or clutch shaft out of alignment—see fig. 3, page 732.

Ridge worn on the rear of clutch leather—see page 660 for remedy.

*Clutch Spinning.

When a clutch spins, when thrown out of engagement, it is difficult to shift gears.

Clutch spinning is often due to excessive friction in the spring thrust bearing (see fig. 16), though sometimes faulty alignment of the flywheel and clutch cone prevent the engaging surfaces from entirely clearing each other. A bent clutch shaft might be the cause of this.

Sometimes the fault lies in the clutch, a heavy rim or cone will store up energy and continue to revolve when disengaed.

When a clutch spins from lack of alignment or adjustment the remedy is obvious, but if the fault is in the design, a clutch brake (see fig. 16 and page 660, fig. 10), should either be fitted, or the clutch rim lightened by drilling or machining away metal at or near the outer circumference.

Cone Clutch Lubrication.

Lubrication of a cone clutch is usually at the rollers or clutch yoke and ball thrust bearings—otherwise oil should be kept from the clutch leather as much as possible as a leather faced cone is supposed to run dry, but yet kept flexible, which it can be by use of Neat's foot or castor oil as explained.

If Clutch Fails to Release.

Usually termed as a "frozen clutch." This may be due to rusty or tight pedal connections or loose pedal linkage connections; clutch yoke rollers run dry and sometimes, from too tight a spring adjustment.

The amount of movement between the surfaces of a clutch is small and it is **important that no looseness in the pedal connections or bending of the levers should exist** to prevent gradual engagement.

A Clutch Brake.

If it is desired to atach a clutch brake or dampener as explained on page 660, to check the revolving of the cone, either cork or rubber can be fitted into a metal bracket and this bracket attached to the car frame.

The position of the brake should be just to the rear of the clutch rim, against which the clutch will draw when the disengaging pedal withdraws the cone.

Miscellaneous Clutch Pointers.

Fig. 1: A clutch or jack can be placed as shown to hold clutch out while working on it.

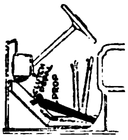


Fig. 1.

Fig. 2: The cone can then be turned by hand and Neats foot oil applied, or oil gun of kerosene for cleaning.

Fig. 3: An insect powder gun, filled with talc or powdered Fullers earth for temporary remedy of an oily slipping clutch or brake.

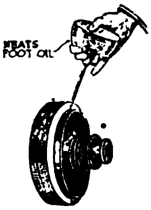


Fig. 2.

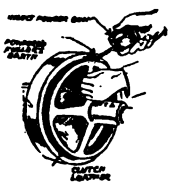


Fig. 8.

Another Example of Adjusting a Cone Clutch—The Mitchell.

Clutch adjustment. The only adjustment of clutch is the three coil springs "C" (fig. 17) which tend to keep the clutch engaged. While it is possible to increase the tension of these springs to avoid slipping of clutch, the tension should be as little as possible. Drawing the springs up too tight will not only make it harder to disengage, but will tend to make clutch grab.

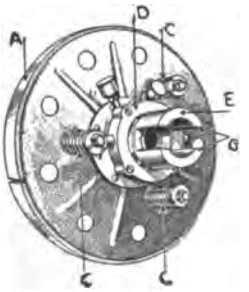
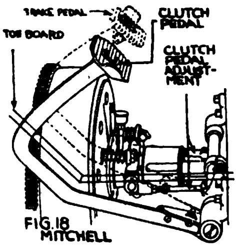


Fig. 17.



Clutch pedal adjustment: The left foot pedal, which actuates the clutch, can be adjusted for different positions by adjusting the two rods connecting the clutch pull shaft with the clutch yoke, but care should be taken to see that both rods are adjusted the same (see fig. 18.) Care should also be taken that the rods are adjusted so that when pedal is depressed clutch will fully disengage and that **pedal does not strike toe-board when clutch is engaged.**

---

*The shift of gears by gear shifting lever ought to be made without a particle of noise if clutch is thrown out when shifting. If there is noise, then it is usually due to clutch not being fully thrown out or dragging or spinning or transmission shaft, or transmission shaft out of line due to worn bearings.

*The Disk Clutch-Adjustments and Repairs.

There are a number of cars in use **having disk clutches on which the adjustment is made by means of a series of three or more separate studs or screws.** Much trouble often is experienced by motorists who try to adjust this type without a knowledge of how it should be done.

Adjustment Method.

The proper way to adjust this type of clutch is to unscrew or release them entirely from contact with the plate or mechanism inside the clutch casing, then screw them up carefully with the fingers until each one just begins to touch, which is indicated by an increase in the effort required. When each screw or stud has been turned up so that it just begins to touch the plate or mechanism against which it bears on the inside of the clutch casing, then with the aid of a wrench, give each screw a half-turn forward and repeat, until the proper adjustment is obtained. The object is to give each screw the same number of turns and at the same time have them all move forward at practically the same time. If one was to give one screw five or six full turns and proceed to the next one and give it the same number of turns, etc., until all had been turned up the same amount, the same results might be obtained; but it is most probable that the job would not be successful, and perhaps damage to the internal mechanism of the clutch would ensue as a result of possible binding or cracking. On the other hand, if the studs were screwed alternately, little by little, but no care given to the relative number of turns given to each, the springs or operating mechanism would most likely bear unevenly upon the disks, and a jerky, grabbing or slipping action of the clutch would result.

**Slipping of Lubricated Disk Clutch.

When an inclosed disk clutch which runs in oil has been giving good service for a reasonable length of time and then develops a tendency to slip, or perhaps to take hold too fiercely, the trouble should not be taken immediately for an indication that the clutch is in need of adjustment. Before altering the adjustment of a clutch of this type, one should first drain out the old oil, inject a pint or more of kerosene, preferably with a squirt gun, then close the opening to the casing, start the engine, and with the gear-shifting lever in the neutral position, operate the clutch pedal so the kerosene may be thoroughly distributed and the internal mechanism of the clutch well rinsed and cleared of old and sticky oil. Then drain the clutch casing, flush it out once or twice with fresh, clean kerosene, and refill to the required amount with clean oil.

If after this treatment the clutch still slips, draw out a little of the oil and replace the amount taken out with kerosene; by thinning the oil this way better contact between the plates is obtained and slipping is reduced. Unless the proper proportions of oil and kerosene are known, the lubricant may have to be thinned down gradually until the proper mixture is obtained; but once found, the extra trouble is rewarded by a fine, smooth action.

Should it be found slipping cannot be eliminated by means of thinning the lubricant, then an increased spring tension may be required, which can be obtained by tightening or screwing up all adjusting studs evenly all around. It is good motor practice never to disturb an adjustment unless having an absolute knowledge of the operation and effect of the adjustment.

**Clutch Grabs or is Fierce.

When a clutch of the disk type running in oil takes hold too fiercely, drain out the oil, rinse with kerosene as previously described, and refill to the required amount with clean, fresh oil; if this does not prove a remedy, readjust the clutch by loosening all studs entirely and then tightening them until best action is obtained.

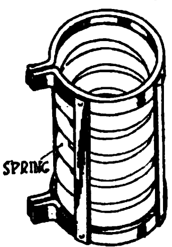
When clutch is new, there may be a slight tendency to slip, owing to the stiffness of the fabric with which the driving disks are lined. No adjustment of the spring is necessary to regulate this condition, as it will entirely disappear after the car has been in use a short time, therefore don't be too hasty in making adjustments.

*The Single Plate Clutch.

Is the type of clutch which is most gengenerally used. This type runs **dry** and is the simplest of all clutches. see page 42 and page 668.

†Replacing Clutch Springs.

In replacing a series of springs, such as clutch springs, it is usually advisable to compress the spring in a vise and then hold it in this position until it is put in place on the car. Under certain circumstances the device shown will be found very convenient. It holds the spring by friction, and consists merely of two clamping rings. As soon as the spring is in place the retaining screws are loosened and the tool is removed.



Internal Expanding Clutches.

Internal expanding clutches, in which metal acts on metal, sometimes give trouble from the melting of the metal due to the heat of excessive slipping. This will lock the two parts of the clutch together so that pressing on the pedal will not release them.

To separate them, the engine must be stopped and the high speed gear engaged. The car should then be pushed forward and backward by hand, which will jerk the clutch and release it.

The same trouble occasionally comes with friction cone clutches that are too fierce, and they may be separated in the same manner.

---

*See pages 543 and 545 for types of clutches used on different cars; page 666 Hudson; 40 for Cadillac clutch and pages 42, 668 for single plate clutch. See page 667 for Reo clutch, pages 666, 932, Dodge.

**Usual cause of slipping of lubricated disk type clutch is due to improper clutch spring or clutch pedal linkage adjustment which prevents clutch plates from engaging. If this type clutch drags, it is likely due to oil being too thick. If it grabs; likely due to lack of oil or improper clutch spring adjustment. See pages 668, 842 for adjustments and troubles of a dry disk type clutch. See pages 666 and 931 for Dodge clutch.

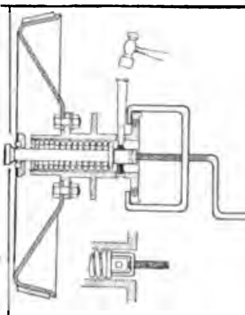


Fig. 1—Showing the method of compressing the clutch spring, permitting the lock pin to be removed.

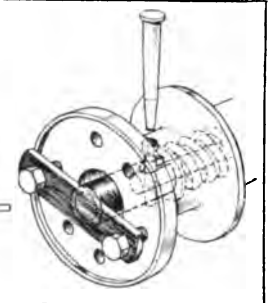


Fig. 1A—Another form of clutch spring compressor, somewhat simpler than that shown in Fig. 1.

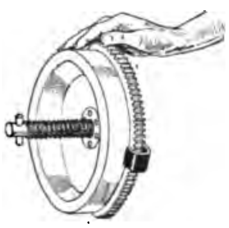


Fig. 2—The thrust bearing assembly is held together by three old valve springs, placed in the manner shown.

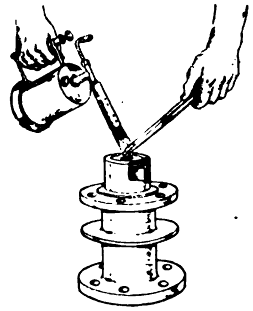


Fig. 4—When loose, the plug in the end of the clutch hub should be sweated back in place.

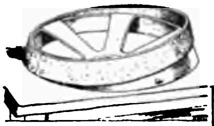


Fig. 3—The new leather should be fastened at the ends, and then forced over the face of the clutch.

Chevrolet "490" clutch repair as an example.

Evidence of Trouble.

1—A heavy grinding noise when the clutch is released. This is usually caused by worn or broken balls in the clutch thrust bearing.

2—Actual failure of the pedal to release or move the clutch or to come back into position when pushed out: This indicates that the clutch spring retaining plug has become unsoldered and has unscrewed from the clutch hub.

3—Excessive slipping of the clutch, that cannot be cured either by application of Neat's foot oil, if dry, or Fuller's earth, if slippery.

The first necessitates a complete removal of the clutch, together with the flywheel and anchor stud; the second a removal of the clutch hub, and the third the removal of the hub and clutch.

Procedure.

1—Remove floorboards.

2—Remove wiring running from battery to starter.

3—Remove the three bolts holding V-brace to engine base and gearbox support and remove the V-brace.

4—Disconnect brake rods from pedals.

5—Remove bolts holding clutch release shaft to gearbox support and remove clutch release cross shaft, together with pedals.

6—Remove bolts on rear clutch hub drive ring.

7—Remove the four bolts holding gearbox to gearbox side arms. (Care should be taken in removing the shims under the gearbox, so they may be replaced in the same position.)

8—Remove one bolt holding the left gearbox side arm (on the pedal side) to engine. (This permits the gearbox side arm to spring to one side in removing the gearbox.)

9—Lift gearbox up and slide it forward. It may then be removed from the chassis. (A jack should be placed beneath the propeller shaft to hold it in place when the gearbox has been removed. In some cars it is necessary to spring the gearbox arms apart or to force the gearbox out with a jack.)

10—Turn the flywheel until the hole passing through the clutch hub is at the top, and the clutch spring retaining pin is in line with the hole.

11—Using either the compressor shown in fig. 1 or 1A; compress the clutch spring. The clutch spring retaining pin will usually drop out when over the hole in the housing; but, if not, may be driven out with a drift and hammer.

12—Draw clutch spring out.

13—Remove bolts holding clutch hub to clutch spider, and remove clutch hub. (This is necessary, as the hub would otherwise interfere when removing the clutch.)

14—Pull clutch out. (This will take some little effort, as the gearbox arms squeeze onto the clutch and must be sprung. But it can be pulled out.)

15—Remove nuts holding flywheel to crankshaft flange and with a bar loosen flywheel and remove. (It is advisable to mark the position of flywheel on the flange so it may be replaced in the same relative position.)

16—Remove flywheel together with clutch spring anchor stud and place in on two boards nailed to the bench.

17—Separate all parts and clean with gasoline and waste:

Clutch Troubles.

Clutches of this type give but little trouble if properly used and the necessity for relining is only occasional. If **slipping** has been experienced and the leather is damp, it is usually because it has been soaked with mineral oil. This may be removed by cleaning the leather with gasoline, after which Neat's foot oil should be applied to keep the leather flexible.

Grabbing. Though a dry clutch will occasionally cause slipping it more usually causes "grabbing." Unless the leather is burned, or worn out, it may be restored by roughing the surface slightly with emery paper, and then dressing it with Neat's foot oil.

Another cause of a sticking clutch is protruding rivets, and these should again be set beneath the surface of the leather. A small shoulder will also cause trouble, and this should be scraped or filed down.

A new leather should never be fitted unless it is absolutely certain that the old leather cannot be reclaimed.

If relining the clutch is imperative, it is best to obtain the new lining from the makers. If this is not expedient, the old lining should be carefully removed and used as a pattern for cutting the new lining. The new leather should be much thicker than the old lining and of uniform thickness.

The most essential point in fitting the new leather is to have it fit tight and true to the cone.

If the clutch has been relined it will not work perfectly until it has been worked in. This usually takes some time and during that period should receive frequent applications of Neat's foot oil.

To Fit a New Leather.

1—Soak the leather in water.

2—Secure one end of the leather to the cone by one copper rivet (rough side out.) (Never use anything but copper rivets; other metals will score the metal clutch facing.)

3—With only about three-quarters of the leather on the cone, pin the other end to the cone by a rivet. (see fig. 3.)

4—Force the leather up into the cone. It should fit evenly and with uniform tension.

5—Drill and countersink the rivet holes.

6—Rivet the leather in place. Be certain that the rivet heads are 3-32 in. below the leather and well headed on the inner side.

7—Allow the leather to dry slowly. It will otherwise shrink too much and expose rivets. A coarse file may be used to remove the high spots.

—Continued next page.

CHART NO. 268—A Cone Clutch Repair—Chevrolet "490" as an Example—see charts 229 to 232 for types of clutches used on different cars.(see pages 671 and 672 for Chevrolet transmission and rear axle adjustment.)

—Continued.

Clutch Hub Repair.

If the solder holding the clutch spring retaining plug has become loosened, permitting the plug to unscrew—

1—Clean and scrape both plug and hub end thoroughly.

2—Screw plug into hub until the upper surface is slightly below the hub.

3—Heat end with torch, as shown in fig. 4, and run solder into the joint.

Thrust Bearing Repair.

1—Examine the balls and races of this bearing, and if pitted or showing the slightest indication of wear, the entire assembly must be replaced.

2—Place flywheel on bench, as shown in fig. 2.

3—Force ball race into flywheel casting. This must go in evenly and come to a seat evenly, otherwise the bearing will quickly destroy itself.

4—Assemble the balls and clutch spring anchor stud, packing the balls in grease.

5—Slip the clamp shown in fig. 2 (page 664), over the end of the stud. This holds it firmly in place and permits one man to put on the retaining springs.

6—Slip on three old valve springs over the end of the stud and pin in place, as shown. The clamp may now be removed and the stud, with the thrust bearing, cannot fall apart in reassembling the clutch.
An alternative method, and one commonly used in assembling the anchor stud and bearings, is to place the ball race, balls and anchor stud together before placing them in the flywheel They may be held together by the three valve springs.

7—Lift flywheel back into place on the engine. Bolt it back in the same position as removed. Do not tighten any one bolt until all are drawn snug. This removes the possibilty of having the flywheel out of true, which would ruin the thrust bearings.

8—Remove the pin and three old valve springs from the clutch spring anchor stud.

9—Force the clutch back into position.

10—Bolt clutch hub to clutch spider. Draw all bolts up snug, before any one is tightened.

11—Put clutch spring back in place and pack with grease.

12—Using the compressor shown in fig. 1 or fig. 1A, replace the clutch spring retaining pin.

13—Lift gearbox back into frame. It will have to be sprung past the gearbox side arm.

14—Replace bolt holding gearbox side arm to engine.

15—Replace the bolts on rear clutch hub drive ring. Bring all up snug together.

16—Replace bolts holding gearbox to side arms. (Make certain that the shims are replaced exactly in the same position from which they were removed.)

17—Replace clutch release shaft with clutch yoke and pedals.

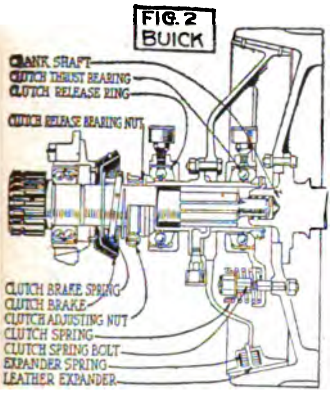
18—Connect brake rods.

19—Replace V-brake, connecting gearbox support with engine.

20—Refill oil reservoir on clutch yoke and grease cups on clutch cross shaft. Oil all working parts.

21—Replace wiring. Start engine and note whether everything seems to be working properly. If there is a rattle in the clutch drive ring it will indicate that the gearbox is out of line. The shims will have to be shifted or possibly removed. When perfect alignment is reached the rattle will cease.

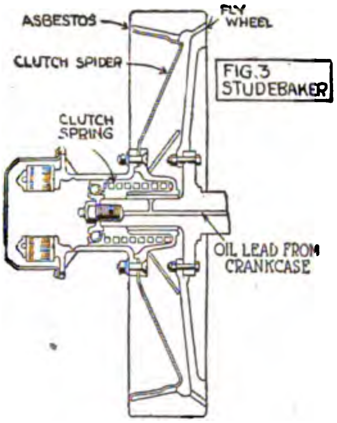
FIG. 2 BUICK



Buick clutch showing adjusting feature and parts which need oiling

Fig. 2.

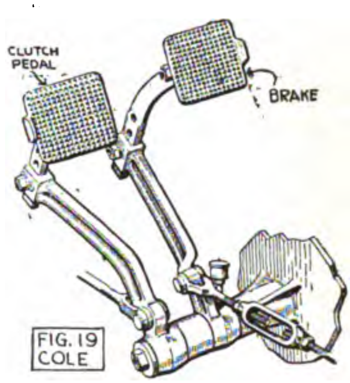
FIG. 3 STUDEBAKER



The simple Studebaker clutch. Tension is maintained by one main spring

Fig. 3.

FIG. 19 COLE



Foot pedals may be adjusted (for height) by removing the bolt and placing portion of pedal (inserted in fork) where desired.

*Buick 4 Cylinder Car Clutch.

Fig. 2—Buick clutch is a cone clutch. Here again, the regular antidotes for slipping clutch caused by a worn, oily or burned leather, apply.

A worn leather may be made to hold by increasing the tension on the four large clutch springs within the clutch spider. In doing this be careful to turn the nuts exactly the same amount.

When the lining of the clutch brake becomes worn, thus allowing the clutch to spin after disengagement and make the shifting of gears difficult, adjust by loosening the clamp bolt and turning the adjusting nut to the left or counterclockwise. This will compress the brake spring sooner and consequently stop the clutch more quickly.

To grease the clutch, loosen the wing nuts and remove the cover of the clutch housing. Give the grease cup on the clutch release ring a turn or two. Press the clutch pedal and turn the clutch cone around until that grease cup appears and give it a turn or two. Turn the engine over until the grease cup on the clutch spider appears and turn that down the same amount. Apply a few drops of flowing oil to the clutch release yoke trunnion bearings. This operation should be performed every 500 miles.

Studebaker Clutch.

Fig. 3—Studebaker clutch is of the leather-face cone type to which general rules for the care of the leather, renewals, etc., given elsewhere in this book, apply. The clutch bushing is lubricated by an oil lead, bored through the center of the crankshaft which takes lubricant from the oil reservoir of the engine. If, after long service, new linings on the clutch fail to make the device hold properly, the remedy is to wash with gasoline and treat with neat's foot oil.

To remove the main clutch spring; this can only be done by completely disassembling the unit, and either increasing the tension of this spring by stretching it out, or replacing it. On rare occasions these springs will break, and of course the only remedy is to replace the spring.

HART NO. 264—Cone Clutch Repair—Continued. **Buick, Studebaker Cone Type Clutch Adjustment. Foot Pedals.** *See index for Buick "six" clutch, which is a multiple disk type.

Overland Clutch.

Fig. 19. Cone type, leather faced. **Clutch tension** is by 3 powerful springs, per fig. 3, page 647 and fig. 17, page 660. **To remove** springs use pry, per page 647. **To increase spring tension,** turn nuts in. Each nut to be turned same amount.

Care: turn grease cups down once a week and keep supplied with oil. Oil ball-thrust bearings every 500 miles, which can be easily reached by oil can to side of clutch spokes.

See also, pages 660, 647.

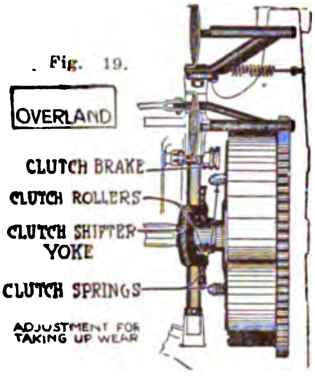


Fig. 19.

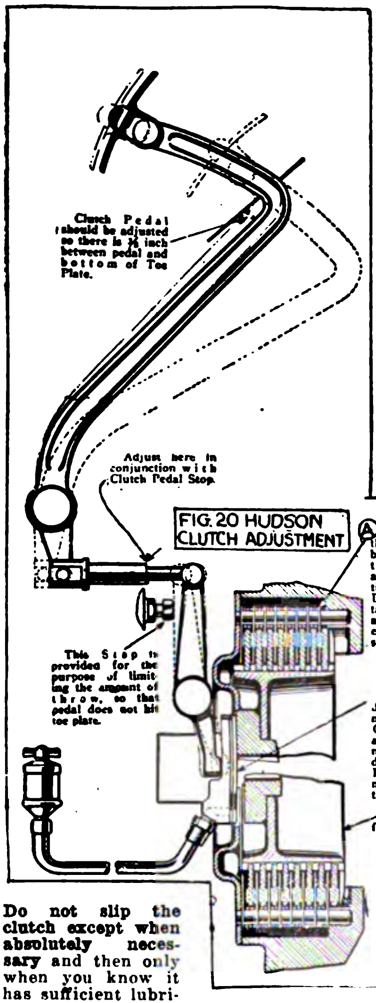

Clutch Pedal should be adjusted so there is ½ inch between pedal and bottom of Toe Plate.
Adjust here in conjunction with Clutch Pedal Stop.
This Stop is provided for the purpose of limiting the amount of throw, so that pedal does not hit toe plate.
Ⓐ If sufficient throw-out cannot be obtained thru the adjustments, an earlier separation of Clutch Discs can be obtained by placing a 3/32 inch washer on each driving stud at this point.
Wear of Clutch during first 500 miles moves Clutch Collar away from Clutch necessitating freedom of Clutch Pedal so it can move farther up thru Toe Plate.
Showing Clutch fully disengaged.

FIG. 20 HUDSON CLUTCH ADJUSTMENT

Do not slip the clutch except when absolutely necessary and then only when you know it has sufficient lubrication to stand it. If you feel that you must do so, owing to lack of confidence in your ability to handle the car through congested traffic, remember that the **lubrication of the throwout collar will need more frequent attention.**

*Dodge Cone Clutch and Transmission.

Fig. 4. To adjust clutch: Remove cover plate, loosen clamp screw on clutch-adjusting nut and turn up clutch spring adjusting nut (just below clutch "throw-out" fork) with a screw driver until sufficient compression. Then tighten screw.

Care: keep clutch yoke grease tube filled and be sure it does not clog. Keep drain hole in bottom of clutch housing free so oil cannot accumulate on clutch leather. Turn grease cup down often, on "clutch-throw-out."

Transmission lubrication: Use 1 part medium grease and 2 parts 600W steam cylinder oil and up to ½" of main shaft—see page 670.

*Dodge Dry Disc Clutch.

There are 7 discs held together by a heavy spring (6, fig. A, page 931). The 4 **driving** discs (9) (covered with wire woven asbestos), are supported on 6 pins (3), pressed and riveted into fly wheel. The 3 **driven** discs (8) (plain), are carried on 3 pins (7) riveted to clutch spider (4) which is keyed on clutch shaft (32). Fly wheel pins (3) are located outside, or above the clutch spider pins (7), so that they can turn independent of the clutch spider pins when clutch is disengaged. All discs are free to slide upon their supporting pins and are held together by the clutch spring (6) when clutch is "in."

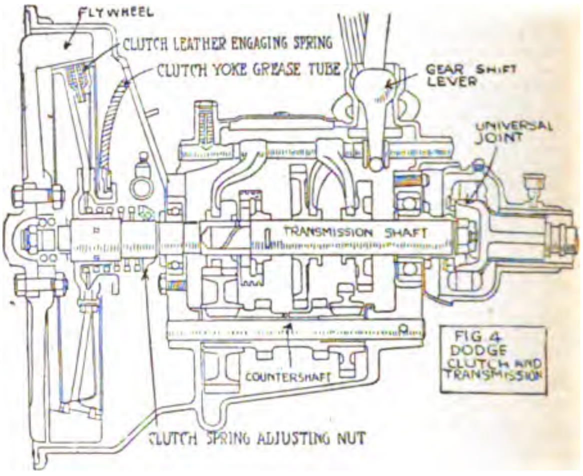


FIG 4 DODGE CLUTCH AND TRANSMISSION

To tighten clutch spring: compress enough to allow split washer (see fig. 1, page 932), which fits into one of three grooves cut on clutch shaft, to be moved forward to the next groove. The two halves of this washer must fit securely into groove so that clutch spring rear retainer fits snugly around it.

Care: Keep foot off clutch pedal except when used, otherwise disc facings and ball-bearing throw-out will wear excessively. **Do not** slip clutch unnecessarily, as this causes fabric to become glazed and slip. Keep drain in bottom of clutch housing open.

Lubricate ball bearing clutch release (12) by keeping grease cup, located on the toe board to the right of the accelerator pedal, well filled and give it one complete turn every 100 miles. Make sure that the clutch release grease tube (34, fig. A, page 931), is tightly connected and unobstructed.

Hudson Clutch.

Fig. 20—Hudson clutch is the lubricated disk, cork insert type.

Renewing the oil and lubricating the clutch throw-out collar are the only attentions necessary.

The fact that the cork inserts become saturated with oil makes it comparatively difficult to abuse this clutch as compared with other types. However, its action will be affected if instructions in regard to the quality and quantity of lubricant are not strictly adhered to. Never put more than a half pint or mixture in at one time. Always drain the clutch to remove the used oil before filling in any fresh oil. **Half kerosene and half good engine oil.**

Clutch adjustment (see fig. 20), should be inspected occasionally.

CHART NO. 265—Examples of Cone Clutch and Disc Clutch Adjustments.

*The first 50,000 Dodge cars used the "cone" clutch as above. **Later cars use disc clutch,** dry type—consisting of 4 driving and 3 driven members. **See page 931, 670** and Insert No. 1. See page 689, Dodge Brake Adj-

Reo Dry Disk Clutch.

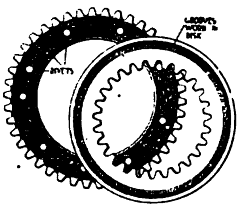


Fig. 1—If worn, the facing should be renewed, and the rivets countersunk below the surface to prevent grooving the steel disks. The steel disks should be renewed if grooved or warped.

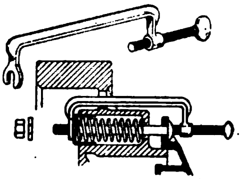


Fig. 2—The assembly is facilitated by the use of a simple compressor, applied in the manner illustrated. It is cast iron, though a similar one could be forged from bar stock. The main thing is to use a compressor of some sort

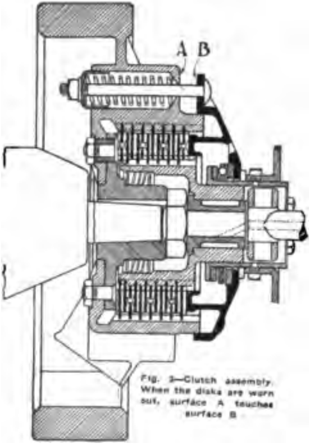


Fig. 3—Clutch assembly. When the disks are worn out, surface A touches surface B.

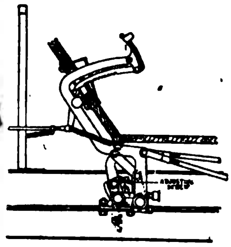


Fig. 4—To adjust clutch opening fingers, turn the adjusting screw on the clutch pedal until the clearance between the fingers and the release plate is about 1/16 in when the clutch is in. The release plate should then spin freely

Evidence of Trouble.

1—**Slipping clutch:** This is often caused by lack of proper clearance between the clutch opening fingers and the release plate. This clearance should never be less than 1/16 or more than ⅛ inch, when the clutch is in. This necessitates an adjustment of the clutch opening fingers. (see clutch adjustment below.)

Another cause of slipping clutch is too little tension on the clutch springs, contained in recesses in the flywheel, as shown in fig. 2. The nuts on the engine end should be tightened enough to prevent the clutch from slipping, but not enough to make the pedal difficult to operate. Never tighten the clutch spring nuts until the release fingers have been adjusted to the proper clearance. Neither of the above adjustments will have any effect if the lining on the disks are worn so thin that the clutch casing seats on the flywheel, as shown in fig. 3, at A and B. When worn thus, the clutch must be removed.

Continual slipping cause the disks to get very hot, warping the steel disks, as shown in fig. 1, and raising the rivets on the lined disks so that they cause the clutch to chatter, with the possibility of grooving the disk and giving them a permanent warp.

2—**Noisy clutch—particularly when released:** This is due to worn clutch thrust bearing. (see fig 3.) A removal of the clutch and replacement of the bearing is necessary.

To Remove the Clutch.

1—Remove floor boards.
2—Remove starter driving chain.
3—Remove the two battery wires running to starting motor.
4—After removing the two bolts holding the right end of the starter, and the single bolt at the left end, remove starting motor.
5—Remove short drive shaft, with its universals, that connect clutch and gearbox.
6—Remove brake rods.
7—Remove bolts on clutch cross shaft and spring it up.
8—Remove clutch cross shaft.
9—Remove the nuts that hold the clutch spring bolts at the rear of the flywheel. Remove bolts.
10—Pull clutch out and remove from frame.
11—Place clutch ring assembly on bench with clutch rings up.
12—Remove snap ring and then remove all friction rings.
(Note how the rings are removed that they may again be built up in the proper sequence.)
13—Clean all parts with gasoline and scrape out the clutch ring recesses both on the flywheel and the clutch hub.

The Repair.

If asbestos faces of the disks are worn they must be replaced. The split rivets holding them should be opened down below the surface, if the facing does not have to be renewed.

1—To replace facing: Cut off heads of old rivets, taking care that the disks are not sprung out of shape.
2—Examine each disk to see that it is not sprung or warped out of shape, and note whether the steel disks are grooved. If either is the case the disks must be replaced.
3—Using each disk as a template, drill the rivet holes in its new facings. Countersink the facings slightly for the rivet heads.
(The new facings can best be obtained from the car makers, and this should be done if possible.)
4—Using solid copper rivets, rivet the new facing to the disk.
5—Examine ball and roller bearings of the clutch for wear and the clutch bushing for looseness. Replace with new ones, if any amount of wear is evident.
6—Use little grease in assembling the bearings, as the clutch must be run dry.

1—**When assembling clutch:** Make certain that the rings are inserted in proper relation to each other. (An asbestos faced disk goes in first.)
2—Slide clutch back into place.
3—Using clutch spring compressor, as shown in fig. 2, replace nuts on clutch spring bolts. Do not tighten these nuts yet.
4—Replace clutch cross shaft.
5—Reconnect brake rods.
6—Replace drive shaft and universals.
7—Replace starting motor, wires and driving chain.

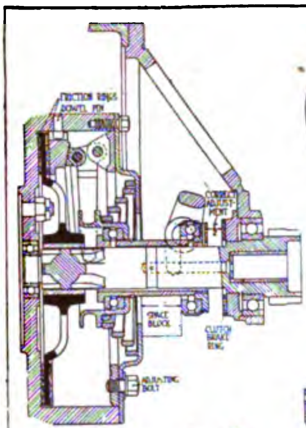
To Adjust Clutch.

1—Adjust opening fingers on clutch throwout collar so that they strike the collar together. This is done by loosening the clamp bolts, holding them to the cross shaft and tapping them into alignment. If this is not done the gears will not shift readily.
2—Adjust the clearance of the opening fingers. This is done by loosening the lock nut on the set screw, as shown in fig. 4, and turning the screw in to decrease the clearance and out to increase. This screw should be turned out until the clutch release collar spins easily on the drive shaft when the clutch is in.
3—Tighten the nuts on the clutch springs at the rear of the flywheel, evenly, and until the clutch does not slip. These nuts should not be tightened so that the clutch pedal works with difficulty

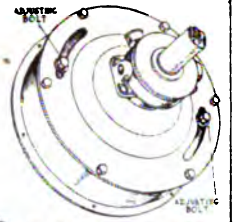
Maintenance.

1—If the clutch starts to slip, adjust it at once.
2—Use no oil on the interior of the clutch, except as placed in the two oil openings in the drive shaft
3—Do not drive with the foot on the clutch pedal.

CHART NO. 266—Dry Disk Clutch Repair and Adjustment—Reo Fifth as an Example.
(Motor World.)



Left—Fig 1—The important parts of the clutch are marked. Note the correct spacing of the clutch brake, the position of the space block, the dowel pin, and friction rings.



Right—Fig. 2—By loosening the two adjusting bolts and shifting them in a clockwise direction, the clutch is tightened.

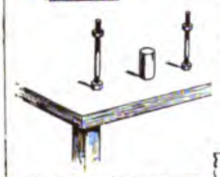


Fig. 3—Detail of a simple clutch compressor.

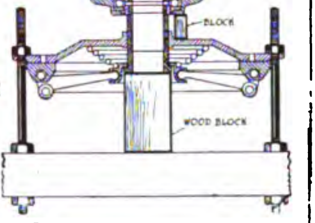


Fig 4—The clutch compressor in use. If an arbor press is at hand, it may be used in a similar manner. Note the block that is used to hold the clutch in the out position.

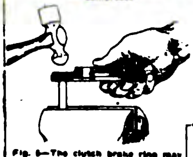


Fig. 5—The clutch brake ring may be riveted to its flange, but the friction rings of the clutch should run loose in their working seats.

Borg and Beck Dry Disk Clutch.

Evidence of Trouble.

1–**Grinting or clashing of the gears,** especially the first speed gears when shifting.
This indicates that the facing of the clutch brake (see fig. 1) is worn and must be either adjusted or relined.

2–**Continual slipping of the clutch** that cannot be stopped by draining and cleaning with gasoline or by adjustment.
This may be due to either excess oil in the clutch casing or to worn friction rings; the excess oil may leak in through the dam which separates the front oil reservoir from the flywheel case. The transmission must be removed and the clutch taken down.

3–**Slipping of the clutch, followed by chattering and grabbing.** This indicates that the asbestos friction rings are glazed and should be replaced, requiring that the clutch be removed.

4–**Actual failure of the clutch to operate, or excessive noise when the clutch pedal is pushed out,** indicating that the clutch spring or some of the operating members are worn or broken, and hence necessitating a removal of the clutch.
(Ordinarily a washing and adjustment of the clutch will place all parts in good condition. Unless it is positively indicated that a removal is necessary, cleaning and adjustment should always take place before tearing the clutch down.)

To Clean the Clutch.

1–Remove drain plug at bottom of clutch housing.

2–Remove clutch inspection plate.

3–Loosen clutch flange retaining bolts holding flange to flywheel. Do not loosen these bolts more than ¼ in.; just enough to allow the oil to drain out.

4–Squirt a little gasoline into the clutch, washing out the residual oil.

5–Tighten clutch flange bolts.
The clutch may slip for a short time until all the oil has been squeezed out. But if it continues to slip or grow worse there must be a leakage from the crankcase that must be stopped, and hence the clutch must be taken down.

If clutch grabs: Take out one of the adjusting screws (see A, page 842) and apply a mixture of 2/3 lubricating oil, 1/3 kerosene, through this hole with an oil gun. As a rule, a bath of kerosene is all that is necessary. Sometimes, merely tightening clutch spring will remedy the trouble. If neither of above, then see 3, under "evidence of trouble."

To tighten clutch—see pages 43 and 842.

To Repair Clutch Brake.

This brake is designed to stop the spinning of the clutch and to prevent gears clashing when shifting. To examine:

1–Press clutch pedal way down.

2–Examine brake and see whether it actually touches the collar or not. If it does not touch, the transmission must be removed. Note how far it comes from touching.

3–Remove gearbox. This method may vary somewhat in the different cases.

4–Examine clutch brake friction band. If in good condition, it will not be necessary to install a new one, as a metal washer placed between it and the shoulder on the main drive pinion will raise it sufficiently to touch the brake. The thickness of this washer depends on the distance the clutch brake and flange were apart, as shown in fig. 2.

5–Unscrew clutch brake (this is a left hand thread) and place the metal washer between it and the drive pinion. It is better to reline the clutch brake after washers amounting to ⅛ in. have been installed.

6–If the clutch brake facing is worn very thin or glazed it should be removed and a new one riveted on in its place. Copper rivets should be used, and they should be countersunk well beneath the surface of the facing. (see fig. 5.)
Providing the adjustment of the clutch is O. K. and the friction rings are in good working order the gear box may now be assembled.

To Remove Clutch

Necessitated by worn clutch rings, actual failure of the clutch to operate or continued presence of oil after repeated cleanings.

1–Mark clutch cover and flywheel so that the cover may be replaced exactly as removed. If the cover should be replaced wrong, the clutch will not operate.

2–Throw clutch out and lock by placing a block of wood (space block) as shown in fig. 1.

3–Remove clutch cover bolts.

4–Draw clutch out.
If all working members are in good condition and not worn excessively new friction rings should be slipped in place and the clutch assembled. It may however, be necessary to completely dismantle the clutch in order to replace the spring or some worn member.

To Dismantle Clutch.

1–Place clutch on compressor, shown in fig. 4, and tighten the stud nuts.

2–Remove the distance block.

3–Unscrew retaining collar.

4–Remove stud nuts of fig. 4, permitting clutch to come apart.

5–Examine all parts for wear and replace worn parts.

6–Reassemble clutch, using compressor shown in fig. 4.

7–Place distance block in position and remove clutch from compressor.

8–Place friction ring, then clutch plate in flywheel, followed by the other friction ring.

9–Then put the clutch assembly in place, making sure that the dowel pins, or set screws, are in place on the inside rim of the flywheel, and that they fit into the slots of the driving plate.

10–Replace clutch, cover bolts, making sure the cover is on the same position as removed.

11–Replace transmission, drive shaft, etc.

12–Check up adjustment of pedals and clutch as outlined, and see that clutch brake is working all right.

13–Grease all parts and replace miscellaneous fittings.

HART NO. 267—Care and Repair of a Dry Disk Type of Clutch—The Borg and Beck as used on many different cars—see page 543, also see pages 42, 43 and 842.
(Motor World.)

*Overhauling the Gear Set or Transmission.

Usual troubles are: (1) stripped gears; (2) bearings worn permitting shaft to drop out of alignment (see page 732); (3) dogs worn and will not catch; (4) dripping oil from gear box.

The cause of dripping oil is due to either a loose gasket (fig. 2, chart 291), or to too much oil—running out at the bearing, or worn felt gasket sometimes used. Carry the oil level slightly below the secondary shaft. The lower gears will splash oil to all parts—see pages 203 to 205. (Note Overland uses grease—(see page 670—see Dodge 670, 666.)

Causes of the Other Troubles.

When dogs become worn (see part No. 139, page 48), so that they slip out of engagement, they may be dressed up or squared by grinding.

Noise: In gear boxes where shaft ends are supporter by single row ball bearings, with no provision for end thrust and are **noisy—replace bearings.**

Considerable wear in bearings will change the distance between centers of the transmission shaft—**replace bearings.**

Difficulty in shifting gears: Three reasons: (1) sticking or dragging clutch caused by heavy oil; (2) teeth of shifting gears burred; (3) considerable wear in bearings—throwing shaft out of line, which also causes noise.

End play—may be discovered by grasping the universal joint behind the gearset and attempting to move it forward or backward. If looseness is found, adjustment is needed. If end play is allowed to develop gears are likely to be stripped.

To determine cause of clashing gears: remove cover plate over clutch and, with rear wheel jacked and car in gear, let clutch in and out. If clutch continues to spin after it has been thrown out, look to clutch brake or too close an adjustment or heavy oil—causing gears to drag.

Note: Don't allow a nut or any chips of metal to lodge in transmission case—it will strip the gears if caught between the teeth. This also applies to engine and differential.

Don't use waste to wipe out the interior of a transmission—it leaves lint.

Speed Gear Ratios.

The gear ratios on transmissions of three speeds (Warner as example) is; (1st) speed, 2.5 to 1; (2nd) speed 1.7 to 1; (3rd) speed 1 to 1; (reverse) 3.4 to 1.

On four speed gear sets it is approximately, (1st) 3.6 to 1; (2nd), 2.07 to 1; (3rd) 1.32 to 1; (4th) 1 to 1; reverse 3.9 to 1 or 6.1 to 1.

The average ratios will be about as follows: 1st 3.24 to 1; 2nd 1.95 to 1; 3rd 1.19 to 1; 4th 1 to 1; reverse 4 to 1.

Rear Axle Pointers.

The three types of rear axles in general use are the Semi-floating, ¾ floating and Full-floating, as explained on page 33.

To find the type used on leading cars, see pages 543 to 546. On these pages, the make of axle as well as the type is given. For the Ford axle, see supplements. For the Marmon axle, a ¾ floating type, see page 32.

The S. A. E. distinction between the three types of axles is as follows:

Semi-floating—Inner ends of axle shafts are carried by differential side gears (differential carried on separate bearings). Outer ends of shafts are supported by bearings.

¾-floating—Inner ends of shafts carried same as in semi-floating. Outer ends of shaft supported by the wheels (only one bearing is used in each wheel).

Full-floating—Same as ¾-floating except that each wheel has two bearings (wheels do not depend on the shaft for alignment.)

Advantages of the semi-floating axle (by Packard Motor Car Co.) In the semi-floating axle, the wheel hubs can be made slightly smaller and because of location of bearings, the stresses in rear axle can be kept lower than in the full-floating type.

There is a slight advantage also in the bearings, as the full floating type have to use a bearing with a smaller ball, since it must fit around the rear axle tube. In the semi-floating type, the bearing has a smaller bore, and therefore, larger balls can be used as it has only to go over the axle shaft.

Another advantage is; the rear wheels can be more readily removed when replacments are necessary — wheels being replaced oftener than shafts. **Still another advantage claimed is that of lubrication;** as the outer bearings can be lubricated from the inside, and an oil retainer placed on the outside, whilst the full-floating type must have a separate supply of lubricant to the rear wheel bearings.

Pointers on Removal of Differential.

Removal of differential in a semi-floating axle and some ¾-floating axles; the entire rear axle assembly must be removed from the car. For instance, see Ford Instruction

The axle must be removed from car, as shown in fig. 1, page 675. The axle housing is usually divided in the center.

After housing and wheels are removed, the axle is then disassembled as shown in figs. 4 and 5.

Removal of differential on all full-floating axles is done by withdrawing the axle shafts, leaving the wheels supporting the car and housing intact, as explained on page 679 (Studebaker). The differential can then be drawn from rear of housing by removing cover plate (fig. 1, page 677), or drawn from front of housing with drive shaft.

In the full-floating type the axle housing is seldom divided in the center.

How Axle Shafts are Fastened.

The semi-floating axle shafts are fastened to the differential by different methods. In some it is by means of a tapered pin, and key, others by split clamps which fit over heavy threaded portion of shaft end; still others by the use of Woodruff keys or split washers, as per Ford and per Maxwell (chart 273, fig. 5.)

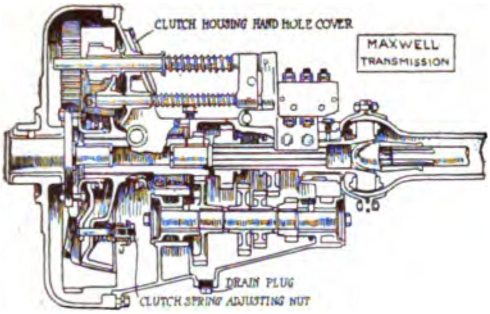
The full-floating axle shaft is not fastened but is either square or "splined." Splines take the place of keyways, see fig. 7, page 680.

Removal of Wheels.

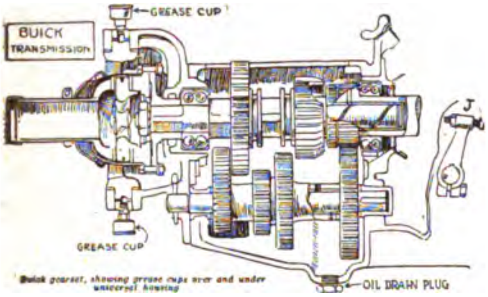
For removal of wheels see page 677. Pinion adjustments etc., see pages 673 to 679.

---

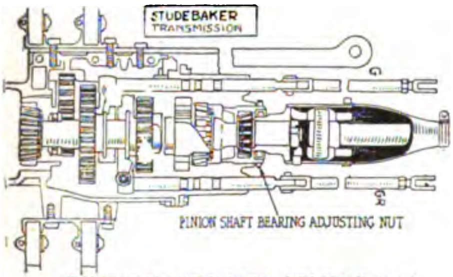
*See pages 543 to 546, "Specifications of Leading Cars," for types of axles, gearsets, etc. on leading cars. The **M & S locking differential**, mfgd. by M & S Gear Co., Detroit, is a popular type for truck axles.



Cutaway sketch of Maxwell gearset and clutch. The clutch-adjusting nuts are shown.



Buick gearset, showing grease cups over and under universal housing.



Studebaker rear axle gearset showing pinion shaft bearing adjusting nut

Studebaker Transmission.

Studebaker gearset—The Studebaker sliding gear is a unit with the rear axle and is of conventional selective three-speed type. After a great deal of service the gearset pinion shaft may need adjustment in the suspending bearings.

To determine whether or not adjustment is needed endeavor to push the universal back and forth and if the shaft shows play where it enters the gearset case, it indicates that the roller bearings need taking up. The operation is performed through the pinion shaft adjusting nut. This nut is locked by a pawl and the pawl, in turn, is locked by the lock bolt which holds the adjusting nut. Loosen the nut on this bolt and the pawl can be removed from the adjusting nut.

To make the adjustment, turn out the adjusting nut until the play between the shaft and gearcase disappears. It is not necessary to draw the nut up excessively tight When the operation is completed, lock the units in the inverse operations by which they were unlocked.

A light gearset grease is advised for oiling.

Buick Transmission.

Buick gearset—The main shaft of the Buick gearset is ball-bearing mounted. To lubricate, it should be filled with steam-cylinder oil, which is about the heaviest flowing oil obtainable, and to do this the filler cap on the right side of the gearset case must be removed and the case filled to the level of the opening.

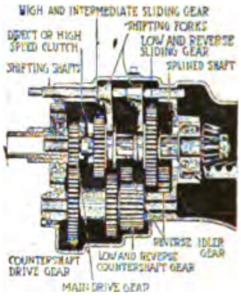
Maxwell Transmission.

The Maxwell gearset is conventional sliding gear. three speeds forward and reverse. Bearings are non-adjustable, but if properly cared for should not need renewal.

To oil the gearset, remove the filler plug in the top of the gearcase cover and pour in a very heavy flowing oil, preferably a steam cylinder oil, **until the lower or countershaft gears are about half covered.** When the case is empty this will require about 1 quart of oil. Do not use hard grease.

The clutch used on the Maxwell is a cone type faced with a fabric composition, and runs in a bath of oil. To remedy slipping in the clutch, providing that the fabric facing has not become worn down excessively, remove the hand-hole cover from the forward top of the gearset case and take up tension on the three springs. Each spring should be tightened an equal amount. A grabbing clutch probably means lack of oil or possibly that there is too great a tension on the springs.

The clutch housing should contain from 1 to 1½ pints of lubricant. Ordinary motor oil will give the best results. This oil may be inserted through the inspection plate on top of the clutch housing and should be renewed every 2,000 miles, the old oil being drained out through the drain plug on the bottom of the housing. It is well to flush the clutch with kerosene. See page 675—Maxwell axle.


HIGH AND INTERMEDIATE SLIDING GEAR
DIRECT OR HIGH SPEED CLUTCH
SHIFTING FORKS
LOW AND REVERSE SLIDING GEAR
SHIFTING SHAFTS
SPLINED SHAFT
REVERSE IDLER GEAR
COUNTERSHAFT DRIVE GEAR
LOW AND REVERSE COUNTERSHAFT GEAR
MAIN DRIVE GEAR

*Overland Transmission.

***Overland gearset:** Twice a season at least, the gear box should be opened and filled with kerosene or gasoline and the resulting thin solution drawn off through the opening in the bottom of the gear case. When the case is cleaned, pack with grease, replace the gasket carefully, and screw down the cover.

In disassembling the transmission, the transmission shaft goes out first, the countershaft next, and the reverse gears last.

The right way to replace transmission bearings: The annular ball bearings of the transmission should be replaced as follows:

Place a piece of lead pipe over the shaft and against the bearing in such a manner that the blow will be borne by the outer raceway of the bearing, that is, the one seating in the transmission housing. If the inner or smaller raceway, or the end of the shaft, be hammered upon, the blows are transmitted to the balls themselves and in not a few cases they are broken. (see chart 277).

**Dodge Transmission.

—**The Dodge gearset** main sliding-gear shaft is mounted on ball bearings at either end and looseness means replacement of the bearings. The countershaft is mounted on bronze bearings If the gearset is kept properly lubricated with clean oil, none of these bearings should need replacement in a good many thousand miles of driving. Not more than 2 quarts of gearset lubricant should be used in the case. The level should be inspected every 1,000 miles and, **if it has fallen so low that the gears on the main shaft do not dip well into the lubricant,** the supply should be replenished so that they do. **The level should be kept ½-inch below the main sliding-gear shaft**—see also pages 932, 931.

HART NO. 268—Transmissions or Gear Sets—How to Care for and Adjust.

*verland transmission is placed as a unit with the rear axle. **See pages 666, 931, 932, for Dodge transmis-, and page 689 for Dodge brake.

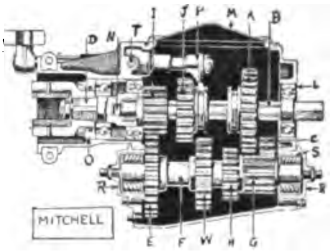
Removing, Disassembling and Assembling Transmission
—Mitchell as an Example.

To remove transmission. Place jack under drive shaft housing to prevent the transmission from falling. Remove and slide back the shell covering clutch hub. Turn clutch until one slot in clutch hub is up and the other down. Remove the two large hexagon nuts holding the transmission to the main cross frame member. By lowering the jack the front of the transmission can be lowered to the floor. Remove the eight bolts holding transmission to drive shaft housing and the transmission can be removed.

To disassemble transmission. Remove main shaft "B" and sliding gears "A" and "J." After the transmission has been taken out of car, the main shaft "B" with the bearing "L" can be withdrawn from the transmission case without disturbing any other part. After top cover plate "M" is removed the two sliding gears "A" and "J" can be lifted out of the case. In drawing out the main shaft care should be taken that the thrust washer "N" does not drop into the case. A good suggestion is to rest the transmission case on the forward end.

To remove gear and spindle. To remove gear and spindle "D" and "I." Remove the small plate in the front side of transmission case (not shown in illustration) through this opening unscrew the collar "O." Gear and spindle with universal joint complete can now be withdrawn. When putting back this part be sure the thrust washer "N" is put back in place.

To remove sub-shaft and gears. After the main shaft and the two sliding gears have been removed as above, take out gear shifting rods "P"; remove reverse idler gear "C" by driving out the short shaft upon which the gear revolves. (Don't attempt to tap inward, this must be tapped outwards from the inside.) (See below, to remove reverse idler gear.) By removing the plug at the forward end of the transmission case in line with the shaft a steel rod can be inserted and the short shaft driven out. Remove the two bearing caps "R" and "R" and move back the sub-shaft "F" until bearing "S" comes from the case. Remove bearing "S" from the shaft. By lifting up the front end of the subshaft it can be taken out through the top of the case.



To remove reverse idler gear. After the large cotter pin through the reverse idler gear shaft at the outside of the transmission case is removed. As an accessibility feature the reverse idler gear can be removed without disturbing any other part. By removing the plug at the forward end of transmission case in line with the short shaft a steel rod can be inserted through the hole and the short shaft driven out.

When reassembling you must be careful that all gears are in the same relative position in which they were originally.

In a socket at the forward end of the case are placed two plungers under the tension of a spring. When the sliding gears are in their proper position these plungers fall into recesses on the gear shifting rods, holding the gears in position. When the gear shifting rods are replaced the plunger can be pushed down so the rods will enter by unscrewing plug "T."

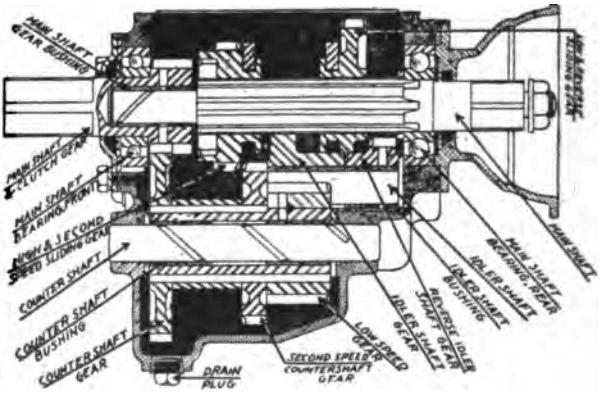
After the transmission is reassembled, test it out before it is reinstalled in the car. Put it in different speeds to see that is it assembled correctly.

Care of Transmission, Chevrolet as an Example.

The transmission is the regular selective type, having three speeds forward and one reverse. The clutch is explained in chart 263.

To lubricate, fill every 1,000 miles with No. 600-W steam cylinder oil, not grease, so that **oil level stands at bottom of the upper or splined shaft.**

To clean: Once every 2000 miles wash out transmission with kerosene to remove any particles of metal worn off the gears or other foreign substances. To do this remove the drain plug at the bottom of the transmission case and allow the oil to drain off, after which flush out thoroughly and refill with oil.



Chevrolet Rear Axle.

This is almost a true semi-floating type of axle. The bearings however are not direct on the axle on the outer end, but are between the housing and rear wheel hub (see fig. 83, chart 270), therefore it is termed a ¾ floating type (see page 669 and 83).

How to remove the rear axle assembly:. Jack up the car and remove bolts and clips holding springs to axle housing. Disconnect all brake rods from foot pedals to rocker shaft mounted on the propeller shaft housing, and slide entire assembly from under the car.

How to remove the propeller shaft: Slide the axle assembly from under the car and remove nuts holding the propeller shaft housing to axle housings. The propeller shaft housing assembly can then be lifted off. Remove the pinion shaft bearing lock stud (fig. 33, chart 270), and with a lead hammer or piece of wood held against the upper or universal joint end of the propeller shaft, drive the shaft and bearings from the housing.

Extreme care should be used not to batter the end of the shaft. If a few smart blows do not start the bearing, examine it carefully. Probably a burr is holding it or the inside edge of the housing may have become battered over. The drive pinion and bearings can then be removed by unscrewing the nut on the end of the propeller shaft.

Replacing drive pinions: Should it become necessary to replace the drive pinion, extreme care should be exercised to see that the tapered hole of

HART NO. 269—Removing and Disassembling a Transmission—Mitchell and Chevrolet as examples

—continued from Chart 269.

the gear fits the taper on the shaft snugly and at all points. Always, before putting the new pinion on the shaft, remove the cotter pin holding the adjusting nut and turn the nut back two or three turns. As it is impossible to machine two tapered holes exactly alike, one gear may "go on" a little farther than the other, so if the adjustment were not changed the gear would "shoulder" against the bearing before obtaining a good seat on the shaft.

It is a good plan to "try" the fit of the gear on the shaft before finally assembling. The best way is to secure a little Prussian blue and spread it thinly around the bore of the gear. Press the gear on the shaft, then remove and note the marks made on the shaft. If the "bearing" is uneven smear a little valve grinding compound on the shaft and with a reciprocating motion "grind" the gear to its seat. Much depends upon securing a good snug fit, so take your time, as it is a good insurance against roadside repairs. After having secured a good fit, securely lock the nut and spread the cotter pin. **Before fitting the gear examine the key.** If this is loose in the shaft or worn replace it with a new one. The adjusting nut should then be set up and securely locked with a cotter pin. Care must be used not to get the adjustment too tight; however, it should be snug. If the holes for cotter pin will not "line up" without getting the bearing too tight or too loose, make a washer of tin or brass and insert betwen the nut and center thrust bearing washer.

In replacing the propeller shaft and bearings in the propeller shaft housing care must be used not to crowd the bearings. Be sure to line up the hole in the bearing sleeve with the hole in the housing for the pinion shaft bearing lock stud, after which replace the stud.

How to Remove Differential Assembly.

Remove the propeller shaft housing assembly and rear wheels. The axle housing is in two parts, right and left, bolted together in the center. Remove the bolts and slide the housings off the shafts.

The differential gear case is in two halves and can be separated by removing the clamping bolts, after which the axle shafts with the main shaft gears can be withdrawn.

The differential main shaft gears are keyed and pinned to the axle shafts. After removing the pins the gears can be pressed off the shafts.

In reassembling the differential be sure that the two fibre thrust washers are fitted into the recessed ends of the main shaft gears . (see fig. 5, chart 278.) After tightening the clamping bolts be sure to lock them with a wire passing through holes in their heads.

Before sliding the axle housings back on the shafts, examine the differential thrust bearings. If they are worn or roughened, replace them, as these must be in good condition, otherwise there is danger of broken gears.

Once every 2000 miles it is a good plan to test the thrust bearings. To do this jack up the rear of the car so that the wheels clear the ground. Grasp the wheel and push in and pull out. If any play exists it represents the amount of wear on the thrust bearings. If this is more than 3/32 of an inch the axle must be disassembled and new thrust bearings installed.

After the axle is assembled remove the filler plug and pour oil into the housing until it runs out of the filler plug hole. No. 600W steam cylinder oil is the best for summer use and light cylinder oil for freezing weather.

Before connecting the axle with the transmission, pack the universal joint with cup grease.

How to Remove the Universal Joint.

With the axle removed from under the car, take out the five cap screws holding the joint ball retainer collar and pull the ball joint from the socket. Remove the four clamp screws holding the two universal joint rings together (fig. 34) and separate the rings. The nut holding the universal joint yoke to the transmission shaft can then be removed and the yoke pulled off the shaft.

How to Adjust Chevrolet Brakes.

It is important that the brakes be adjusted evenly, that is, that when applied both grip the brake drums with the same pressure and at the same time.

The rods connecting the foot pedals with the brake shaft on the propeller shaft housing are provided with turnbuckles. (See fig. 19, chart 264.) By turning these the rods can be shortened or lengthened, which in turn tightens or loosens the brake bands.

Caution: Do not adjust the brakes too tight, otherwise they will "drag," using up power and wearing out the brake linings in a very short time.

Should one brake "grab" or take hold too quickly, remove the brake operating cable yoke pin on that side and shorten the cables by screwing up the yoke ends.

Care should be taken to see that both brakes are adjusted alike as serious harm will result if one wheel does all or most of the braking; it will cause the car to skid more easily and cause exessive wear on the tire. It also puts an undue strain on the axle parts.

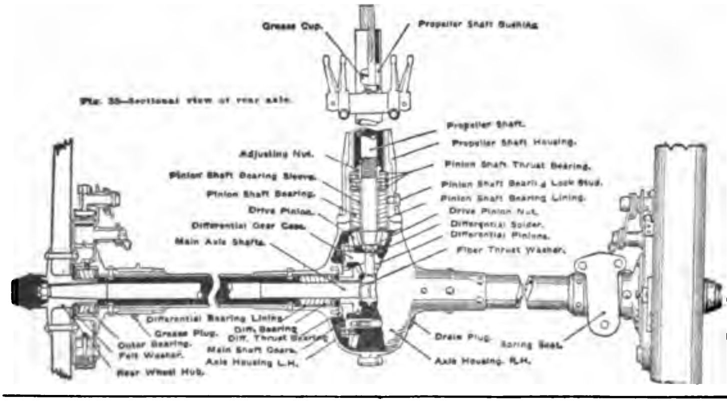


Fig. 35—Sectional view of rear axle.

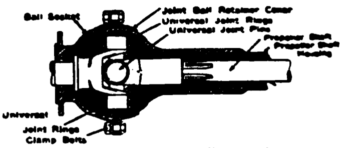


Fig 34—Sectional view of ball and socket.

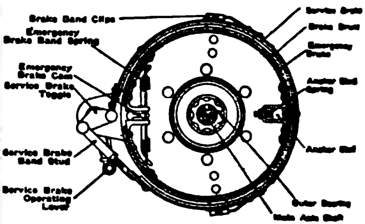


Fig. 36—Chevrolet brake mechanism.

CHART NO. 270—Rear Axle (¾-floating type) and Differential—How to Remove and Replace Parts—Chevrolet "490" as an example.

Chart No. 271 omitted (error in numbering).

Adjusting Timken Rear Axle—Type Indicated Below.

There are three conditions that make adjustment of gears advisable. These are: 1—Objectionable noise; 2—Excessive backlash; 3—Looseness between the bearings on the pinion shaft or at the differential.

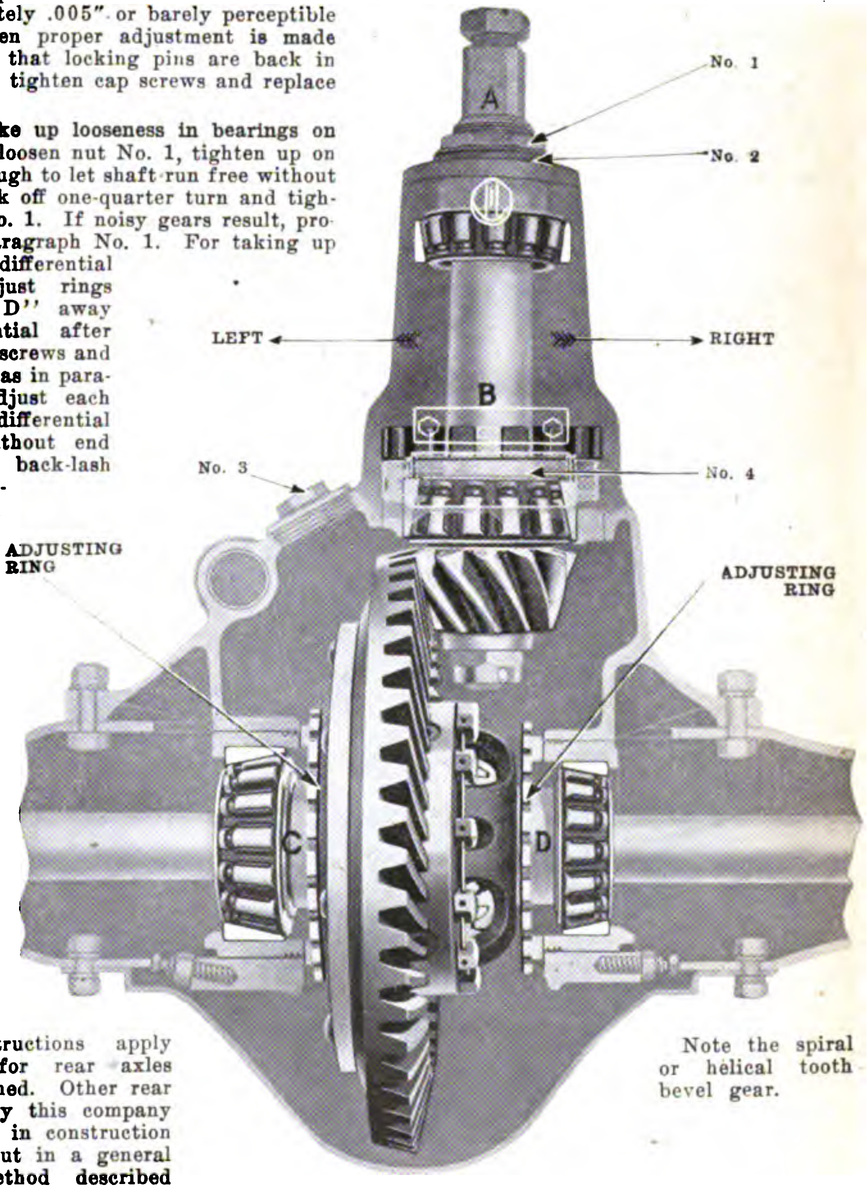
1st.—To eliminate noise, loosen nut No. 1 at "A" and then loosen nut No. 2. Remove the cover at "B" and loosen clamp bolt No. 4. Turn the slotted adjusting cup towards the left, one notch and tighten up nut No. 2, then nut No. 1 just enough to let the shaft run freely without end play. If this lessens the noise, loosen nuts No. 1 and No. 2 and turn adjusting cap another notch and repeat this operation until quietest point is found. If noise increases, adjust in opposite direction. When final adjustment is made so that pinion shaft has no end play, back off nut No. 2 one-quarter turn and tighten up on nut No. 1. Bend washer over one flat of each nut, tighten up clamp bolt No. 4 and replace cover.

2nd—To take up backlash, back adjusting ring at "D" towards differential, (in order to allow the whole unit to slide to the right) and turn ring at "C" against bearing cap which will force gear towards pinion. These rings have right hand thread. Before turning rings, loosen cap screws in bearing cap one-half turn after removing locking wires. (see chart 272-A.) Proper amount of backlash should be approximately .005" or barely perceptible looseness, when proper adjustment is made make certain that locking pins are back in slots of rings, tighten cap screws and replace locking wires.

3rd—To take up looseness in bearings on pinion shaft, loosen nut No. 1, tighten up on nut No. 2 enough to let shaft run free without end play, back off one-quarter turn and tighten up nut No. 1. If noisy gears result, proceed as in paragraph No. 1. For taking up looseness in differential bearings, adjust rings "C" and "D" away from differential after loosening cap screws and locking wires as in paragraph 2. Adjust each ring until differential runs free without end play and if back-lash results, proceed as in paragraph 2.

4th—If gears are so far out of mesh that no result can be obtained through method described above or new gears have to be placed in axle, remove peep hole cover No. 3, for observation and set gears with backs flush, as a starting point, and proceed as above.

These instructions apply particularly for rear axles above mentioned. Other rear axles made by this company differ slightly in construction from these, but in a general way the method described above can be used for other axles also.



Note the spiral or helical tooth bevel gear.

CHART NO. 272—Adjustment of Gears, Timken Rear Axles. Above applies to Timken full-floating axle, numbers 5741, 5742, 5395, 5396, 538 and 574. McFarland (5742); Hal (5395) Daniels (5396); Dorris (5396). (See chart 280B, Adj. Timken Bearings).

Chart No. 271 omitted, error in numbering.

Adjusting Timken Rear Axle—Type Indicated Below.

The same conditions make adjustment necessary as mentioned in chart 272.

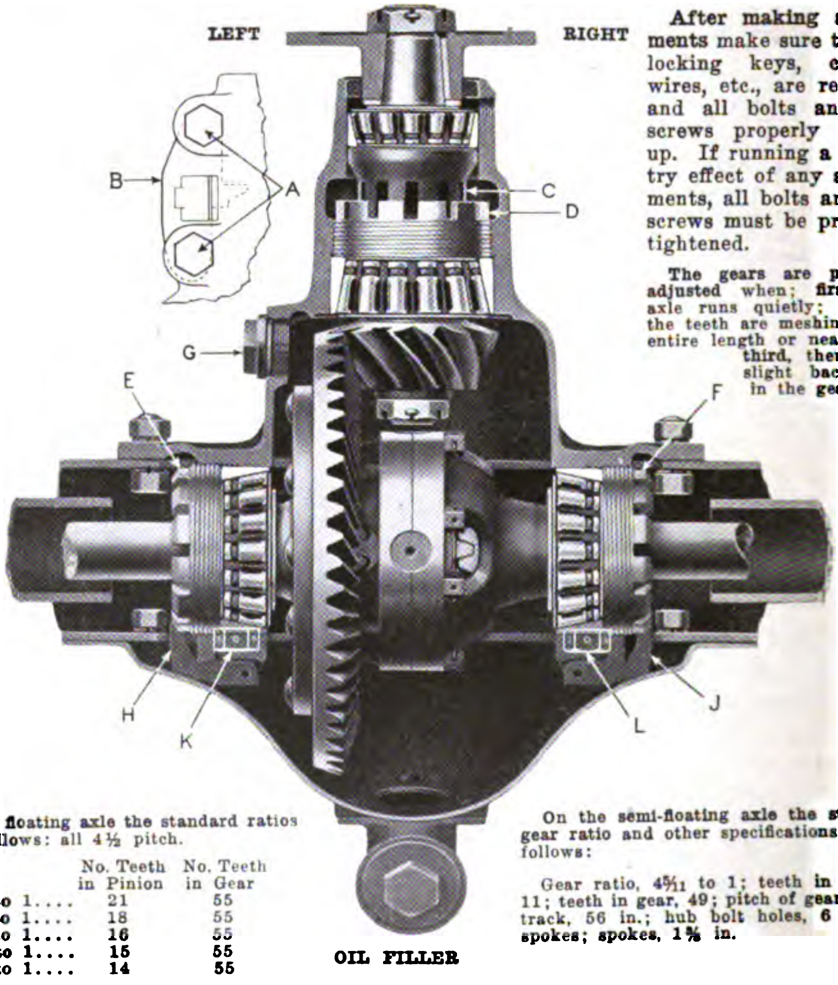
1st—Before making adjustments for elimination of noise or backlash, take up all looseness, if any, in bearings. To do this, remove bolts "A" and locking key "B." Turn slotted ring "C" towards right, while holding ring "D" in its original position, until bearings are free from end play, at the same time allowing pinion shaft to turn free. To take up differential bearings, remove locking wire in cap screws "L" and loosen screws one-half turn. Release locking finger "J" and turn right hand adjusting ring "F" towards differential until bearings are free from end play, at the same time allowing differential to turn freely.

2nd—When adjusting to eliminate noise, remove bolts "A" and locking key "B" as above and turn rings "C" and "D" one slot towards the left and repeat until quietest point is found. If noise increases, adjust in the opposite direction. Always turn rings "C" and "D" together when adjusting for this purpose by using a tool broad enough to engage slots in both rings.

3rd—When adjusting to take up backlash in gears, remove wire and loosen cap screws "K" "L" one-half turn. Release locking fingers "H" "J." Back adjusting ring "F" away from differential and turn adjusting ring "E" towards differential (right hand thread on both) until gear is forced towards pinion so that it has **about .005 inch backlash** or barely perceptible looseness.

If gears are so far out of mesh that no results can be obtained through method described above, or new gears have to be placed in axle, remove peep hole plug "G" for observation, and set gears with backs flush, as a starting point, and proceed again as above.

If noise results from taking up loose bearings, proceed as in 2nd and 3rd paragraphs.



After making adjustments make sure that all locking keys, cotters, wires, etc., are replaced and all bolts and cap screws properly drawn up. If running a car to try effect of any adjustments, all bolts and cap screws must be properly tightened.

The gears are properly adjusted when; first, the axle runs quietly; second, the teeth are meshing their entire length or nearly so; third, there is a slight back lash in the gears.

On the floating axle the standard ratios are as follows: all 4½ pitch.

Ratio	No. Teeth in Pinion	No. Teeth in Gear
2-13/21 to 1....	21	55
3-1/18 to 1....	18	55
3-7/16 to 1....	16	55
3-2/3 to 1....	15	55
3-13/14 to 1....	14	55

On the semi-floating axle the standard gear ratio and other specifications are as follows:

Gear ratio, 4 5/11 to 1; teeth in pinion, 11; teeth in gear, 49; pitch of gears, 4¾; track, 56 in.; hub bolt holes, 6 for 12 spokes; spokes, 1⅜ in.

CHART NO. 272A—Adjustment of Gears in Timken Rear Axles. Above applies to Timken semi-floating or fixed-hub-type axles, numbers 5230, 5240, 5241, 5252 and 35C. Cadillac (5752); Hudson (5241); Jordan (5241); Westcott (5240); Chalmers (35).

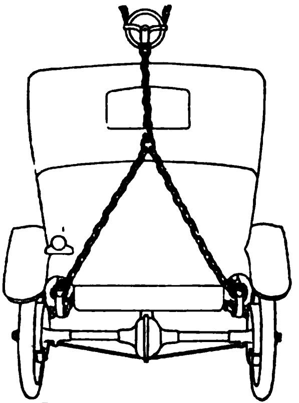


Fig. 1—The car is readily lifted by a chain block and sling. One man can do the work, and the car is held without danger of falling

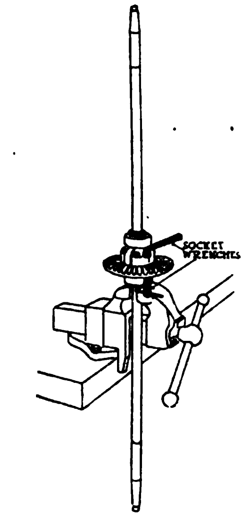


Fig. 4—The differential may be most readily assembled and adjusted, if caught in the vise in this manner. Two socket wrenches are used to do the work

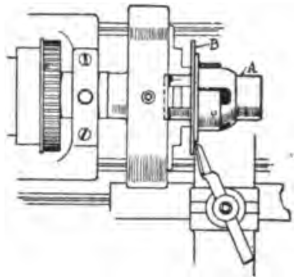


Fig. 6—Breakage of the ring gear usually springs the differential housing flange. By catching the entire housing in the lathe and trueing it up by the surface (A), the ring gear seat (B) may be refaced with a light cut

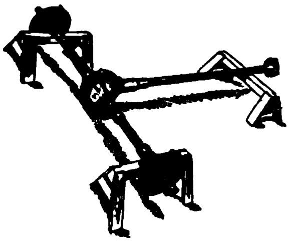


Fig. 2—Three horses form a serviceable axle stand, though a special stand could readily be made. Never attempt to dismantle or assemble a part on the floor but get the work up where it is accessible and clean

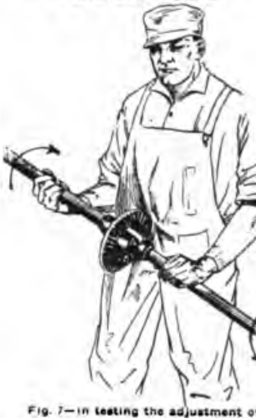


Fig. 7—In testing the adjustment of the differential gears, grasp the assembly in this manner, and turn the axles in opposite directions. They should turn freely all around

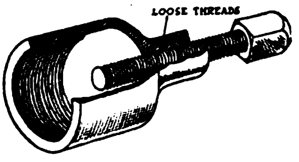


Fig. 3—The feature of this rear wheel puller is that the screw is hardened tool steel, loosely threaded into the cap. The endplay permits a sharp blow on the screw to loosen the sticking wheel

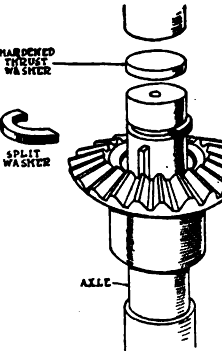


Fig. 5—Don't attempt to remove the side bevel gear from the axle drive shaft until the split washers have been removed in the manner shown

Evidence of Trouble.

1–Any excessive grinding or humming indicates that the gears are either worn, broken, or poorly adjusted.

2–An intermittent catch occurring perhaps only every 100 miles. This indicates that parts of one or several teeth are broken, and are catching in the gears.

3–Actual failure of the axle to operate. **(Any of these necessitates a removal of the axle from the car, tearing down and replacement of defective parts with readjustment).**

To Remove Axle.

1–Block front wheels.

2–Raise rear of car as shown in fig. 1.

3–Disconnect brake rods at the point of connection to the brakes.

4–Remove clips holding axle to springs.

5–Draw axle and housing out to the rear. The driveshaft slips out from the universal and must be caught to prevent possibility of injury to the splined end.

6–Place the axle on three horses arranged as shown in fig. 2.

7–Remove hub caps.

8–Remove axle nuts.

9–Using puller shown in fig. 3, remove wheels.

10–Remove torque tube and driveshaft. Save the gasket.

11–Catch the grease in a pail.

12–Remove nut from one end of axle truss rod.

13–Remove differential housing bolts.

14–Pull off the differential housing halves.

15–Place differential in vise as shown in fig. 4; pull cotter pins from bolt ends and remove differential casing nuts, allowing the two halves to come apart.

16–Remove split washers from end by driving the gear down as shown in fig. 5.

17–Remove bearings and all parts, wash and clean with gasoline.

General Repairs.

1–After cleaning examine all parts for wear. Go over gear teeth, to see if any are broken, or worn. Also note whether driveshaft bevel gear has been wearing evenly along the teeth. The face of the teeth should be bright all over. Any breakage or perceptible wear necessitates a replacement of the gear.

2–Draw driveshaft from torque tube. Clean, and examine bearings.

3–If the axle has been disabled by a collision, the shaft should be caught between lathe centers, tested, and trued up, if bent.

4–If any serious bend is found in either of the shafts, the two halves of the rear axle housing should be bolted together, tested for alignment in the lathe, and straightened.

5–When the large ring gear on the differential must be replaced, its bearing on the differential casing should be trued up in the lathe, as shown in fig. 6.

—continued in chart 274.

CHART NO. 273—The Disassembly and Assembly of Maxwell "25" Rear Axle and Differential.

This axle is a ¾-floating for the same reason as the Chevrolet, chart 270, explained in chart 269. It has the appearance of a semi-floating, but on account of the bearing being between hub of wheel and housing, and bearings supporting differential, it is a true ¾-floating. Axle assembly must be removed and housing stripped from axle. By referring to Ford supplement, chart 328, a true semi-floating axle is shown—outer end of axle shafts connect direct to wheels with Woodruff keys.

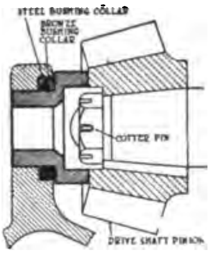


Fig. 8—The cotter pin in the drive shaft pinion lock nut should not interfere with the thrust bushing, and the bushing collars should be inserted in the manner shown

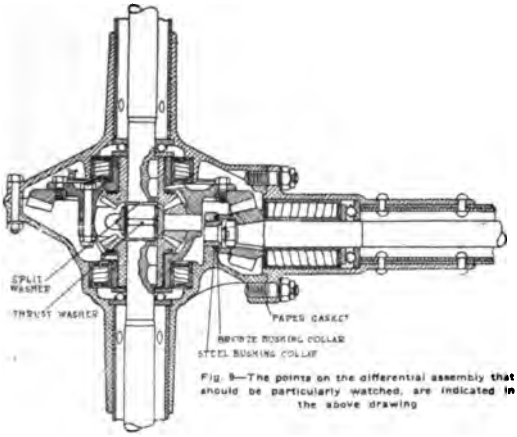


Fig. 9—The points on the differential assembly that should be particularly watched, are indicated in the above drawing

—Continued from Chart 278.

The Reassembly.

1–Replace the shaft bearings, differential housing halves, and shaft gears, making certain that the split washers are in place.

2–Replace differential cross gears on differential cross and holding shaft in vise as shown in fig. 4, bolt halves together. (Be certain that the thrust washer is in place between the ends of the shafts.)

3–When the halves are bolted together there should be about 1-64 in. end play between the two halves of the shaft. If tight, take differential apart and file a little from the end of each shaft.

4–Rebolt the halves, and holding as shown in fig. 7, turn the two shafts in opposite directions. The axles should turn easily all the way around.

(Note—If sticking is noted in any place, catch the assembly in a vise, as shown in fig. 4 and with the tang of a file, find by feeling which cross gear is causing the sticking. If new cross gears have been installed, try changing the sticking gear for a new one from stock. Or if new side gears have been installed, try changing the side gear.)

5–Replace the cotter pins in the differential casing. Clip the ends over, away from the cross gears.

6–Using horses shown in fig. 2, slip the halves of the rear axle casing in place after packing all bearing and gears with nonfluid oil.

7–Bolt the halves together. (Do not pull one nut up tight until the others are snug.)

8–Now get the torque tube, and driveshaft ready for assembly. The shaft should turn freely in the housing. All bearings should be packed in grease.

(Note—If a new driveshaft pinion has been fitted, make certain that the bent ends of the cotter pin in the end of the driveshaft do not interfere with the thrust bushing. (see fig. 8.)

9–Fill axle housing with a good grade of non-fluid oil until the ring gear dips well into the oil.

10–Place first the bronze washer on to the drive pinion thrust bushing, then the steel washer, and insert the bushing into the rear axle housing.

11–Replace the torque tube gasket and slip the torque tube and driveshaft into the axle. Bolt in place.

12–When all bolts are tight; the driveshaft should turn freely under the action of a pipe wrench. If any sticking is noticed, additional gaskets should be placed between the torque tube and the axle. If any slack exists in the gears, the gasket should be replaced by one made of thinner paper.

13–Make certain that the brake levers work freely. Oil well. Note whether the brake bands are wearing evenly and are in good condition. Reline, if necessary.

14–Replace the wheels. Fill hub caps with medium cup grease.

(Note—It is always advisable to grease the rear springs with graphite and grease at this point.)

15–Roll axle beneath car and with one man guiding the driveshaft, slip it into the universal. The splines may not line up at first and hence it may be necessary to crank the engine slowly by hand until the two slide together.

16–Let the car down onto axle.

17–Bolt spring shackles to axle.

18–Reconnect brake levers.

(Note—For the first 200 miles, at least, fill and screw down the grease cups two or three times, to make certain that all bearings have an abundance of grease.)

Buick Rear Axle Adjustment.

Poor Adjustment.

1–A grinding noise. This is usually caused by looseness between the driving gears. It may also be caused by worn teeth. Either necessitates a readjustment.

2–A peculiar click. When letting the clutch in, or when changing gears. This is due to slack in the driving system. Adjustment necessary.

3–An intermittent catch, or one that occurs at every revolution of the wheel. This may be caused by a broken tooth or part of a broken tooth catching. Tearing down necessary.

4–Actual failure of the axle to operate.

Preliminary Test.

1–No preliminary test is necessary if sympton 3 and 4 are present. Tear axle down at once and find cause.

2–To make certain that looseness is present, jack one wheel up and rock that wheel back and forth with the gears locked in high. A 2" travel, marked on the tire is permissible. Any amount greater requires an adjustment. If bevel ring adjustment alone is necessary this may be done by removing the rear axle cover as shown in fig. 1, page 677 and following the same method outlined in adjustment. However, if more than this is necessary it is usually advisable to take the entire axle down, clean the parts thoroughly and make the adjustment when the parts are out where they can be properly seen.

To Remove Axle.

1–Raise car from axle by an overhead chain block or hoist. It can be raised so high that the drive shaft will bind on removing, and it is usually more convenient to do this to render the parts accessible. A horse or block should be placed beneath each runningboard to prevent injury should the hoist fail.

2–Remove front floorboards.

3–Disconnect brake rods.

4–Remove saddles holding the vertical bearings on the driving yoke ring at the rear of the transmission.

5–Unscrew brass packing collar on sleeve of universal joint at rear of transmission.

6–Disconnect rear springs from their supports on the axle.

7–Raise and lower the car until the drive shaft slips from the universal, and slide the assembly out to the rear. (Do not allow the torque tube to drop onto the floor.)

—continued on page 677.

CHART NO. 274—Maxwell Rear Axle Repairs—Concluded. **Buick Full Floating Rear Axle Adjustments**—Continued in Chart 274-A.

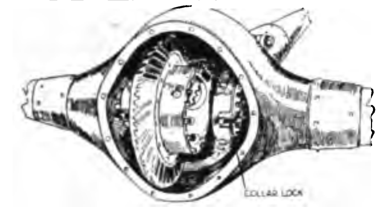


Fig. 1—The adjustment of the bevel ring is rendered accessible by removing the rear cover plate. The collar locks are taken off and then the whole differential assembly may be shifted to the right or the left

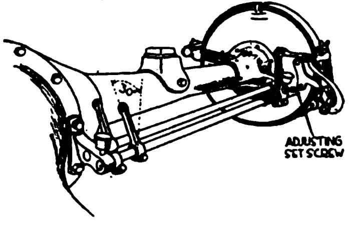


Fig. 2—To adjust service brake: First adjust set screw until bell crank makes 30-degree angle with vertical; make band concentric by adjusting it at rear; then turn butterfly nut until band clearance is 3/64 in.

8–Place the axle across two horses, with the torque tube resting on a third horse.

9–Remove hub caps. (This is not absolutely necessary, but has been found advisable to prevent denting or otherwise injuring them in the work).

10–Remove flange stud nuts holding the driving flange to the wheel hub proper.

11–Draw drive shaft out with driving flange attached.

12–Remove front connections of radius rods to the torque tube.

13–Remove nuts holding main drive shaft housing to the rear axle housing.

14–Pull torque tube forward, removing it from the axle housing. The differential is bolted to this housing, and comes out with it. Place the assembly in a vise. (It is not necessary to remove the rear cover of the differential casing by this method.)

To Remove Wheels.

1–Remove locking rings holding each wheel to the axle housing bearing. The thread on one wheel is left hand and that on the other wheel is right hand.

2–Draw wheel off. The ball bearings in the wheels are not adjustable except for a small amount of end play. If much wear is noted, or the races or balls are chipped, these bearings should be replaced.

3–Examine the brake linings. The emergency, or internal expanding brake, has but little service, and rarely needs adjustment, which is provided on the brake rods, however. If greasy, the linings should be washed with gasoline.

To Adjust Service Brakes.

1–With wheel removed, note whether the band is round, and whether all parts are worn evenly. Uneven wear denotes eccentric bands and this should be corrected by removing the band and springing it back to shape.

2–Measure the clearance between the band and the drum; it should be about 3/64 in. all the way around. If more, the band must be contracted as follows:

3–Turn set screw on outer brake lever so that the lever connected to the pull rod stands at an angle of about 30 degrees, inclined toward the axle housing, fig. 2.

4–Loosen adjusting lock nut on rear half of brake band and turn the adjusting nut until the band is concentric with the drum. Tighten lock nut.

5–Turn the wing nut until the clearance between the brake and the drum is uniformly 3/64 in. (The wing nut should be snapped into its groove in the upper clip before determining the clearance.)

6–Note whether the service brakes on both wheels have the same adjustment. This should be the case to promote even wear and prevent skidding from uneven braking.

7–When installing axle in the car; adjust the brake lever so that the pedal will start contracting the brakes at the slightest pressure.

To Adjust Rear Axle.

1–Remove straps holding differential to the drive shaft housing.

2–Remove differential. It is usually unnecessary to carry the tearing down further, unless the spider gears are worn or some part needs replacing. Any looseness or wear in the spider gears may be felt with the tang of a file.

3–Wash all parts thoroughly with gasoline, get the ring and pinion gear teeth dry and bright. This permits Prussian blue to be effectively used in locating defects that might be responsible for excessive noise.

To Remove Drive Shaft.

1–Loosen cross pinch bolt at the rear of the torque tube.

2–Remove pinion adjustment corner plate exposing pinion adjustment. Mark with a file the exact point the drive shaft projects from the torque tube.

3–Turn pinion adjustment to the right until free. The drive shaft may now be drawn out to the rear.

4–Clean all bearings with clean gasoline and examine all parts for wear.

Rough Assembly.

1–Replace drive shaft.

2–Screw pinion adjustment back until file mark on the drive shaft comes to its former position. The pinion adjustment is then the same as before.

3–Replace differential and bolt in place.

4–Remove any end play in the driving yoke by loosening the clamp screw at the end of the torque tube, and turning the nut until the end play is removed.

5–Tighten clamp screw.

Differential Adjustment.

1–Coat the gear teeth with Prussian blue.

2–With the adjusting sleeve locks removed, turn drive shaft as though the car were going ahead All adjustment should be made on that basis, as the gears are usually working in that direction.

3–Note appearance of the blued teeth after turning as directed. The teeth should show a broad even contact across the entire width of the driving surfaces. Ordinarily the position of the ring gear should not be shifted unless the position of the bevel pinion is also changed, as one depends upon the other.

4–Shift the adjusting sleeves, and the pinion adjustment until the two are balancing, giving a broad contact the entire width of the gear teeth.

5–When properly adjusted the ring gear will have no side play, may be easily turned and spun without noise.

6–Replace adjusting sleeve locks.

7–Replace differential in housing, slipping and bolting radius rods home.

8–Put on wheels. Adjust locking rings so that side play is removed.

9–Replace axles, bolt flanges in place and replace hub caps.

Replacing Axle in Car.

1–Roll axle assembly beneath car. Be certain that packing cap and packing are in place on end of drive shaft.

2–Force splined end of drive shaft into universal joint at rear of transmission. (The car may have to be raised and lowered, and the engine worked slightly to permit this to be done readily, and at the least two men are required to do this.

3–Catch threads of the packing caps in place, and tighten the cap in place. (This may prevent the drive shaft from slipping out before it is anchored by the torque tube.)

4–Replace the saddle holding the lower vertical bearing cap on the driving ring. This may have to be driven into place, until the threads of the retaining bolts catch.

5–Replace upper vertical bearing cup.

6–Lower car, and attach spring ends to axle.

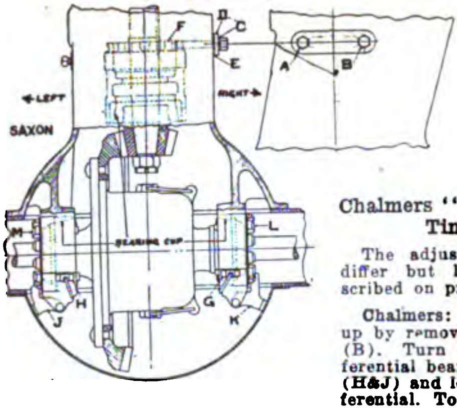
7–Connect brake rods. Adjust foot brake rods by the turnbuckles so that the brakes start to contract at the first presure on the pedal.

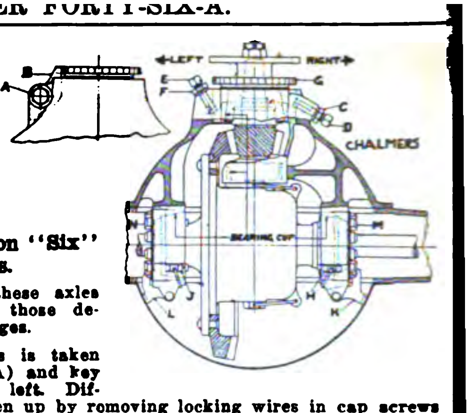
8–Remove differential oil plug and fill housing to level of hole with heavy steam engine oil.

9–Grease and oil all parts.

HART NO. 274-A—Buick Rear Axle Adjustments—A full floating axle. (Motor World.)

Buick 4 cylinder car has ¾ floating axle—See page 543.





Chalmers "35;" Saxon "Six" Timken Axles.

The adjustment of these axles differ but little from those described on preceding pages.

Chalmers: Looseness is taken up by removing bolt (A) and key (B). Turn (G) toward left. Differential bearing is taken up by removing locking wires in cap screws (H&J) and loosen ½ turn. Release (L&K) and turn (M) towards differential. To eliminate noise, loosen (A, F & C). Back off (D) one or two turns and take up on (E) about ¼ turn. If noise is increased, adjust in opposite direction by backing off screw (E), screw in on (D). Be sure (E & D) are locked when finished. To adjust back lash remove wire and loosen cap screws (J & H) ½ turn. Release (L & K). Back (M) away from differential and turn ring (N) towards differential as per instructions in chart 272-A.

Saxon: To eliminate noise, remove screw (A & B) and cover plate (D). Turn (F) one slot towards the left and repeat until quiet—a screw driver can be used. To remove back lash, remove wire and loosen (H & G) ½ turn. Release (K & J.) Back adjusting ring (L) away from differential and turn (M) towards differential until back lash is taken up.

Oil Leakage From Rear Axle.

Preventing the grease or oil in the differential housing from making its way to the brake bands and thus causing inefficient braking was a big problem to manufacturers some years ago, but the difficulty has been overcome largely in all the present types. In all the axle housings on the market, some precautions is taken to prevent this leaking and nine cases out of ten when leak occurs despite this, the condition is caused by **placing too much oil or grease in the housing.**

1—**Showing the double felt washer construction** used on National cars; 2—**Hess axles have a bent axle tube and a felt washer,** making the path of the oil upward in the tube, and only when under abnormal pressure will it work out through the bearing to the washer.

Fig. 3: A sleeve is placed around each axle shaft on the Timken, and when oil is thrown to one side the sleeve acts as a pocket and retains the oil.

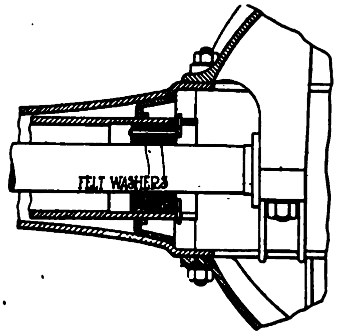


Fig. 1.

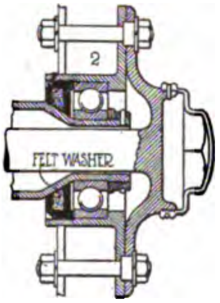


Fig. 2.

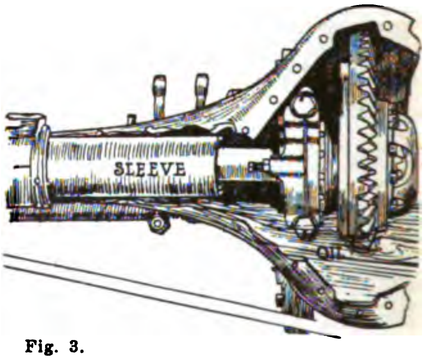


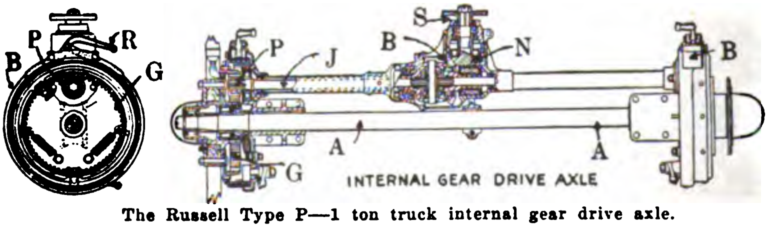
Fig. 3.

The Internal Gear Drive Axle.

This rear axle is used extensively on trucks and differs from usual type in that the rear axle (A) is solid. **An internal gear** (G) is on the inside of wheel hub (D). **A spur gear pinion** (P) drives this gear (G) which revolves the wheel. The **spur gear drive** pinion (P) is driven by a **jack shaft** (J) enclosed in a tube. **The jack shaft** (J) is driven in the usual manner, as a regular split axle, through differential gears and a ring gear (B). **The ring gear** (B) is driven by a bevel driving pinion (N) which is driven by the drive shaft (S) from transmission. Note the differential housing is fastened to the rear axle.

The brake band (B) is of the external contracting type and is controlled by lever (R), which is connected with the foot brake pedal.

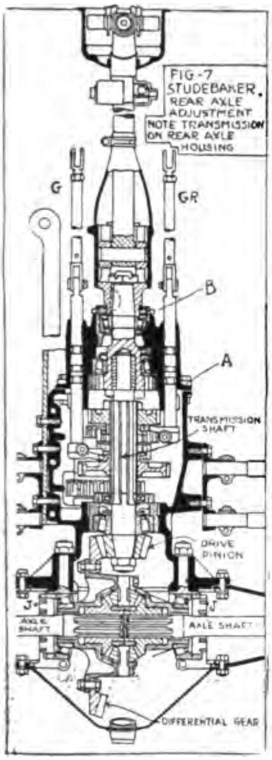
The adjustments on this axle are similar to a "live" split axle, in that the parts necessary to adjust, are the ring gear (B) on differential and bevel drive pinion (N). **The adjustment of the differential ring gear** (B) is to provide the proper center distance for gears (B and N), which can be done by shifting ring gear with adjustments provided. **The adjustment of drive pinion** (N) is to provide the proper mesh between the gear B & N. **Manufacturers of this type axle are; Russell Mfg. Co., Middletown Conn. Torbensen Co., Cleveland, Ohio also manufacture an internal gear drive axle.**

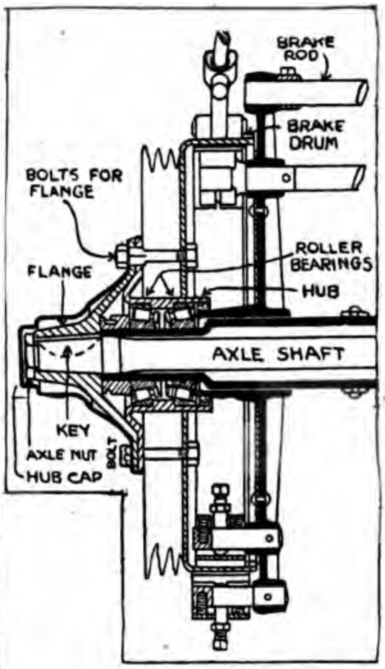


The Russell Type P—1 ton truck internal gear drive axle.

ART NO. 275—Chalmers and Saxon (Timken Axle) Adjustments. Preventing Oil Leakage from ar Axle. Internal Gear Drive Axle.

or grease working out through brake drums cause the brakes to slip. This can usually be overcome by placing felt or leather washer at position shown in fig. 2.





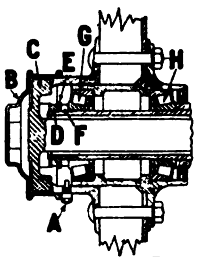
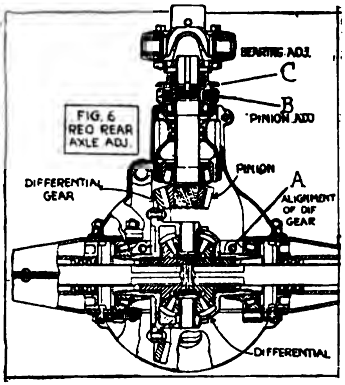


Fig. 47.



Studebaker Rear Axle.

The rear axle is of the full-floating type. In this type the weight of the car is not carried on the axle shafts, but the axle housing extends into the hubs of the rear wheels, and the rear wheels turn on bearings set on this housing, thus relieving the axle shafts absolutely of all weight of the car. Each axle shaft is keyed at its outer end to a driving flange. This flange is bolted to the rear wheel.

By removing the bolts (fig. 6) the flange and the entire axle shaft can be withdrawn, leaving the rear wheel in place and still carrying the load of the car.

Rear wheel bearing adjustment: Jack the wheel clear of the ground. If it indicates play freely when you try to wobble it, the bearing should be adjusted. This can be done as follows:

Take out the axle shaft by removing the bolts at the hub of the rear wheel from the flange. When nuts from the bolts are turned off, the flange and the axle shaft which is attached to it can be withdrawn, exposing bearing adjustment, nut washer, and adjusting lock nut. One of the lugs on the lock-washer will be found bent over, holding the lock nut from turning. Straighten out this lug, and take off adjusting lock nut, also adjusting washer; then turn adjusting nut into the hub until the play between the rear wheel and its bearings disappears. Be careful not to make adjustment so tight as to bind the wheel. When the adjustment is correctly made the wheel should turn freely without wobble. When you have reached this point in the adjustment, replace the adjusting washer, turn on lock nut, and bend one of the lugs on lock-washer over lock nut. Replace the axle shaft and bolt on flange firmly.

Differential: It is advisable at least once a season to clean the differential thoroughly. This can best be done by removing the cover at the rear of the housing and washing out with gasoline. Repack with fresh grease, being careful to replace cover with gasket in perfect condition. The differential can be removed by taking off plate at rear of axle and pulling shafts out far enough to clear it.

Studebaker pinion adjustment on rear axle is made through the nut (B. fig. 7) which adjusts the Timken pinion bearing. To do this, the handhole cover must be removed from the gearcase and the setscrew which holds this nut must be loosened. Great care must be exercised not to adjust this pinion too tight. The rear wheels should be jacked up, the gear lever placed in neutral and the rear cover plate removed.

In aligning the ring or differential, the gear is shifted from one side or the other by turning the adjusting collar (J).

Reo Rear Axle.

Fig. 6—The pinion on the rear axle is adjusted by screwing in the member B; bearing adjustment is accomplished through C and the alignment of the ring gear is shifted from one side to the other by turning the adjusting collars at A. See page 546 for type of axle on the Reo. Note—center illustration shows method of mounting wheel on axle-shaft of Reo.

Removing Cadillac Rear Wheels.

Remove lubricator "A" (fig. 47); remove hub cap "B" by unscrewing it; withdraw axle shaft "C"; jack up the axle so that the wheel will clear the floor; remove the lock nut "D," the washer "E" and the adjusting nut "F"; the wheel can then be taken off.

Re-assembling: Before putting the wheel on again see that the bearings "G" and "H" are clean and filled with light grease which is free from dirt and grit. In putting the wheel on again set the adjusting nut "F" very carefully. Place the washer "E" in position, and tighten the lock nut "D."

CHART NO. 276—Removing Rear Wheels and Axle Shafts; Studebaker, Cadillac and Reo.

All full-floating axles. Therefore the axle shafts can be removed without removing the wheels or axle housing. Note the two bearings in the wheel hubs and splined inner end of axle shafts. (see page 669 and 33.)

Also note that on the Studebaker (and Overland, chart 268) the transmission is next to the axle housing. On the 1918 Studebaker, it is forward, next to clutch.

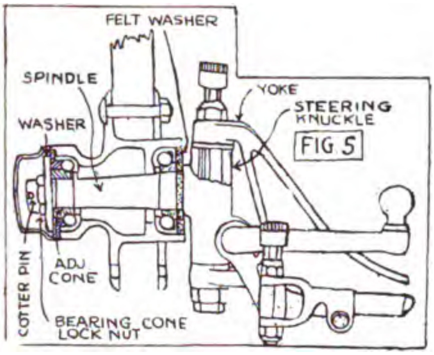


FIG. 5

Removing and Adjusting Front Wheel.

Jack up the wheel and take off the hub cap. Then draw cotter pin (fig. 5) and unscrew bearing cone lock nut. Note: The lock nut on the right-hand wheel (seated in car) has right-hand threads and to unscrew, turn to the left. The lock nut on the left-hand wheel has left hand threads and to remove, turn to the right. When the lock nuts are removed, the wheel can be pulled off very easily as the cone merely slides on the spindle.

Before replacing the wheel, examine the felt washer. If damaged, replace after prying out retaining washer.

Adjusting the ball bearings: In replacing the wheel, press the cone in as far as possible and slide on the retaining washer, then turn the cone until the lug on the washer fits into the recess on the back of the cone to prevent its turning. Tighten up the lock nut until the wheel has no perceptible side play on the spindle, but still revolves very freely; then replace cotter pin and hub cap.

If grease runs out, between hub of front wheel and steering knuckle the cause is due to either too much grease or a defective felt washer.

To see if the front wheel bearings need adjustment, jack up the wheels. Any looseness will show on rocking the wheels sideways.

The best method for adjusting roller bearings (fig. 4), is to turn the bearings up tight, then revolve the wheel a few times by hand; now slack off the nut a little so that by grasping a spoke above the hub and one below, a very slight shake in the wheel is felt, then turn the nut up again slowly until the shake disappears and the wheel revolves freely.

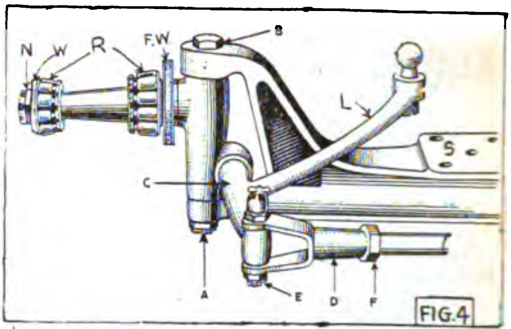
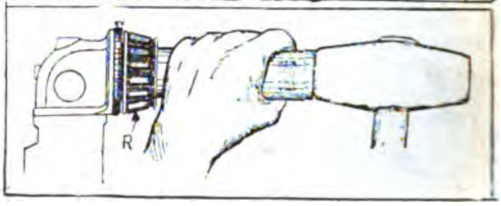


FIG. 4



A good method to get the bearing into position, is to slip a short length of pipe over the spindle, against the inner shell of the bearing, and to drive the bearing to its proper place by hammering on the pipe.

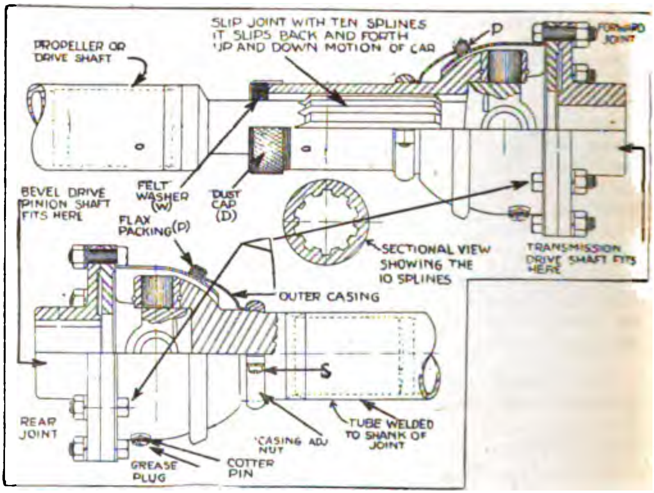

PROPELLER OR DRIVE SHAFT
SLIP JOINT WITH TEN SPLINES IT SLIPS BACK AND FORTH UP AND DOWN MOTION OF CAR
P
FORWARD JOINT
BEVEL DRIVE PINION SHAFT FITS HERE
FELT WASHER (W)
DUST CAP (D)
FLAX PACKING (P)
SECTIONAL VIEW SHOWING THE 10 SPLINES
TRANSMISSION DRIVE SHAFT FITS HERE
OUTER CASING
S
REAR JOINT
CASING ADJ NUT
TUBE WELDED TO SHANK OF JOINT
GREASE PLUG
COTTER PIN

Fig. 7—Spicer Universal Joint.

The Spicer Universal Joint.

The Spicer universal joint is used here for the purpose of an explanation of adjustments and lubrication.

Every 1000 miles remove the grease hole plugs and fill with heavy gear oil or light cup grease. Too much grease will work out; about ⅝ full is correct.

The forward universal joint is provided with a dust cap (D) and felt washer (W) on the rear end of the sleeve into which the end of the propeller shaft slides. This cap should be turned to the right occasionally in order to keep the felt washer tight and prevent the leakage of grease. Both joints have flax packing (P) between the two parts of the pressed steel casings. This packing can be tightened by loosening the bind screw (S) and turning the casing adjusting nut or ring in a right-handed direction.

If the packing in the front universal joint is allowed to leak grease, the joint will not only suffer from lack of lubrication, but the grease will be thrown up onto the emergency brake, rendering the brake inoperative.

Note—Upon examination an "O" will be found on propeller shaft tube upper end; a corresponding "O" will be found on the shank or rear end of the forward universal joint. When propeller shaft and universal joint are assembled these two "O's" must be in line; (as shown in upper drawing fig. 7) otherwise the rear transmission bearing will be subjected to undue strain and excessive wear.

Assembling—When the universal joints have been disassembled and are assembled again, care should be taken to see that the holes in the flange and the inside casings are matched up in such a way as to bring the oil hole (which is closed by a threaded plug) opposite an open space in the joint, and not opposite one of the lugs, which would prevent the introduction of grease through the hole, the intention being that by removing this plug the user of the car can at any time inject additional oil or grease by the use of an ordinary grease gun.

HART NO. 277—Front Axles. Universal Joints.—see also text, pages 681 and 43.

ote—In fig. 5, part designated steering knuckle, is also known as the spindle body (see chart 321.)

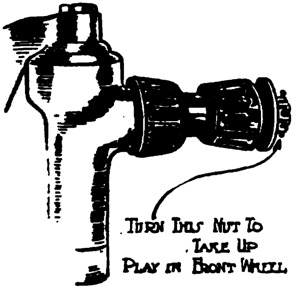
INSTRUCTION No. 46-B.

ADJUSTING WHEELS, BRAKES AND STEERING: Testing, Alignment and Care of Wheels. Camber and "Toe-in" of Front Wheels. Universal Joints. Brake Adjustments and Repairs. Steering Gear Adjustments and Types in General Use.

Front Wheels.

This subject is covered in chart 277, but additional information will be given below.

Testing Play in Wheels.



Taking up play in a front wheel having roller bearings.

Play in the rear or front wheels can be detected by jacking up the car, grasping the rim and working the wheel laterally. (figs. 1 and 4, chart 278.) If the wheel shows looseness the adjustment nut should be tightened. This nut is located within the hub cap and whatever its shape may be, it is made so that a slight turn makes a considerable change in adjustment. Do not have the wheels too tight but turn the nut until the wobble disappears. In case of ball bearing wheels, it would be well to take out all the balls and examine them for wear. If any signs of wear are found, replace the worn balls at once. The ball races should be carefully cleaned with gasoline and freed from the slightest suspicion of grit. The same attention as regards cleaning should be given bearings.

If a "click" is heard when turning front wheels with ball bearings—look for a broken or cracked ball—remove it at once, else it will ruin entire bearing.

Adjustment and care of front wheel bearings: Every time a front wheel is removed the bearing cups are removed with it and consequently the bearing must be properly adjusted when the wheel is replaced, if it is to give uninterrupted service.

The best method is to turn the bearing up tight and then revolve the wheel a few times by hand, which overcomes any tendency for back lash.

Then back off the adjusting nut very slightly, so that by grasping two spokes in a perpendicular line, one above and one below the hub you begin to feel a very slight shake in the wheel. If this is more than barely perceptible, it is too much and the adjusting nut should be a little tighter, but not enough to cause any binding of the wheel when rotated. When you have it **just right**, lock it, and the bearings will give the best of service. (see also chart 277.)

Wheel Lubrication.

Once in every 1,000 miles of running the front and rear wheel bearings should be examined. If one of the rollers should have become damaged it is better to replace all the rollers, to insure that the whole set is of the same dimensions—in which case it is best to order from the factory.

For lubricating wheel bearings use a good, light graphite grease; spread it over and into the bearings and fill the entire hub with it. The bearings should at all times be free from grit, and it is a good precaution to flush them with gasoline whenever you supply fresh lubricant.

Don't fail to see that the felt washer is in place so that grease will not work out between inner part of hub and bearing.

Truing up Wheels.

The wheels may be tested next. This may be done by taking a measurement at a height of about 8 inches from the floor (fig. 2 chart 278). The wheels should next be lined up as shown in chart 279.

**Tightening Hub Caps.

Occasionally hub caps are lost through carelessness in replacing them after lubricant has been applied. While they should be set up snugly, undue force should not be used as the threads of the brass member may become stripped. An excellent plan is to screw the caps up tightly then tap the wrench a light blow with the hammer. Sometimes too much lubricant is used and when tightening the cap, the grease gives one the impression that the cap is snug.

*Universal Joints.

To clean and grease the universal joints in the driving mechanism; first, remove leather boots, if any are provided and clean them with gasoline. In some cars the housing inclosed by the leather boot is a small, cylindrical sleeve held by four set-screws. When these are removed the sleeve may be slipped off the universal joint, leaving this free to be cleaned. All signs of the old oil should be removed and new grease put in. See page 685 for kind of grease to use.

The kind of grease recommended by different car manf'gs. varies, but the oil known as "timing-gear" oil, having a consistency between heavy cylinder oil and vaseline, may be used. Graphite grease is also very good. In some of the more

—continued on page 685.

---

*For a mechanical description see pages 680 and 48.

****On wire wheels** it is very necessary that hub cap be drawn very tight, else a noise and probable damage will result.

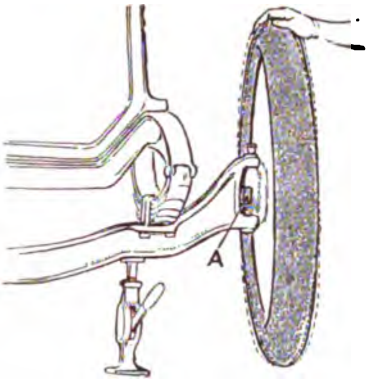


Fig. 1—Testing front wheel bearings: In testing for lost motion in front wheel bearings, a wedge-shaped block or the like should be jammed between the spindle and axle end as shown at A, otherwise lost motion in the spindle or knuckle might be taken for looseness in the wheel bearing. After taking this precaution try to move the wheel as indicated by the dotted lines, and any lost motion in the bearings can be readily felt.

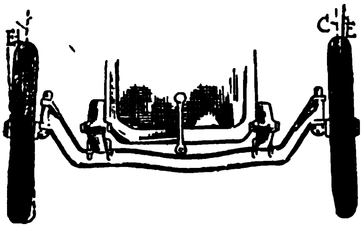


Fig. 3—Sprung axle or spindles: A condition often present in a motor car after a hard summer's use. The wheels should line up as indicated by the lines E rather than as indicated by the dotted lines C. If the wheel wobbles while in operation as indicated by the dotted outline of the right wheel, then the wheel itself is out of true.

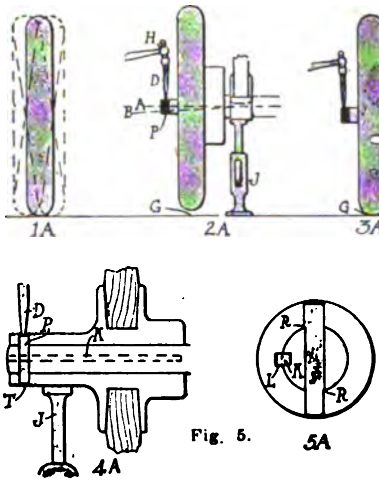


Fig. 5.

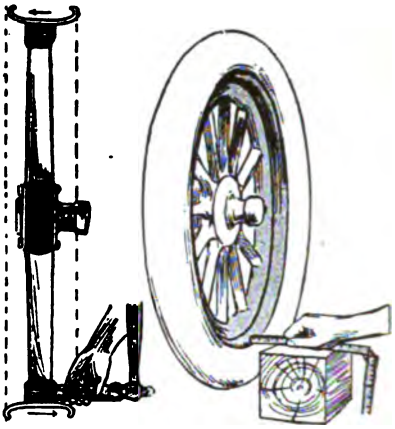


Fig. 2—Truing up a wheel: If a wheel is suspected of being out of true, it may be tested as shown above. With one hand resting on a block to steady it and holding a rule, or the like, close to the wheel rim, the wheel is revolved very slowly; if it is untrue the space between the end of the rule and the wheel rim will vary. If the trouble is simply due to the rim having shifted on the felloe, it may be rectified as indicated at the left in the illustration.

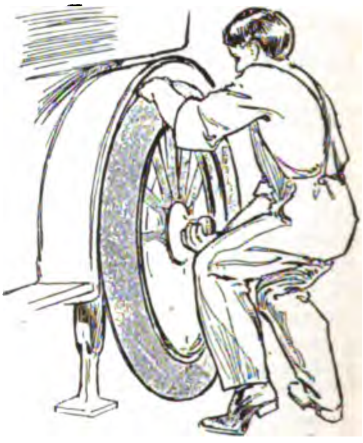


Fig. 4—Testing rear wheel bearings: Lost motion in a rear wheel bearing is best tested for by taking hold of the tire with one hand to steady the body, then working the wheel up and down with the other hand, assisted by the knee and lower portion of one leg. When the right hand is placed on the hub, the right leg is often more conveniently used than the left, as shown in the illustration.

Fig. 5—Rear axle precautions: In removing a rear wheel, an unskilled workman can spring the shaft so that the wheel will afterward wobble as indicated at 1A. This may be done as shown in sketch 2A; with the jack J in the position indicated and the wheel raised from the ground as at G, by using the drift D and hammer H to remove the pin P, a few sharp blows are sufficient to bend the axle as indicated by the dotted lines A and B. This can be avoided if the wheel were allowed to rest on the ground G as in sketch 3A; or by placing the jack J under the hub as shown in sketch 4A. When the key K is loose, as indicated by the dotted lines L in sketch 5A, grooves R may have been worn into the pin which prevent it from being easily removed.

HART NO. 278—Testing Wheel Bearings. Truing up Wheels.

Alignment of Wheels.

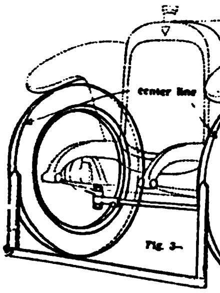
This subject is of more importance than one would imagine. For instance, if the wheels are not properly "lined up" there will be wear on the tire and steering will not be easy. If a car has been subjected to severe jolting or has struck a curb, the wheels may have been thrown out of alignment or the back or front axle moved sideways.

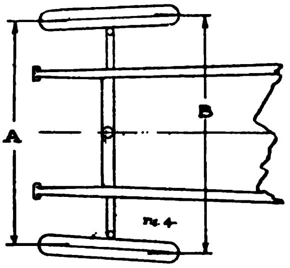
Lining up Springs with the Axle.

Measure distances (fig. 1) from horneye of spring to center of axle as shown at A, B, C and D also X and Y. The distances should be the same on each side of car. Measure with a stiff straight edge of some sort, not a tape line.

Lining up Front and Rear Wheels.

Measure the distance from center to center of hub as at E (fig. 2.) This should be the same on each side. If not, loosen spring clips and move front axle slightly. It will be possible to move either about ¼ inch on most cars.





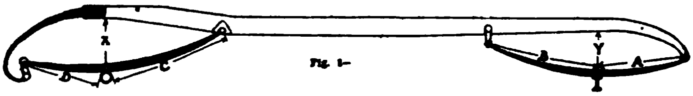
"Camber" of Front Wheels.

Is for the purpose of making steering easier; because wheels have a tendency to spread apart at bottom and come together at the top when speeding.

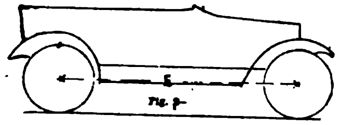
Camber means that the wheels are closer together at the bottom than at the top and the slant is usually, not more than 2 degrees or about 2⅝" for 34" wheels.

This is usually done at the factory by tilting the steering knuckle, if not, then it can be done by bending the front axle between the spring seat and the steering knuckle yoke It is best to bend cold if possible, if heated, don't heat quite red.

The track should then be the same as the rear wheels.



The idea of cambering is to make the center line of spindle bolt coincide as near as it is practical, to center of contact of tire with the ground—see page 774.



True up Front Wheels.

Before proceeding further this is necessary. This can be done by following plan in fig. 2, chart 278. If wheels are wobbly it may be due to loose bearings or sprung rim.

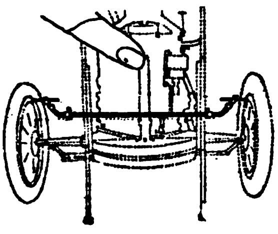
"Toe-in" of Front Wheels.

This means that the distance from center to center of tire as at A (fig. 4) should be from ¼ to ⅜ inches less in front of wheel than at rear as at B—when measured in front of tires about half way up even with the hubs. Don't compare "toe-in" with "camber," as camber means wheels set in at the bottom.

The above measurements are correct for comparatively new cars and should be increased somewhat as the steering knuckles become loosened through wear.

The "toe-in" can be adjusted by adjusting the length of the steering knuckle tie rod, from one steering knucklo to the other. This adjustment should be made with wheels on the ground. The idea of "toe-in" is necessary because when running, the wheels have a tendency to "toe-out" when car is in motion. Unless properly toed-in, if too much or not enough, the treads of the tires will grind.

The front and rear wheels should track, if not, the fault can be detected by the front and rear wheels leaving two distinct tracks behind when running on a wet road.



This illustration shows an auto running gear aligner which has a graduated scale and will make exact measurements. Mfg'd by Mechanical Utilities Corp., 5 North La Salle St. Chicago Illinois.

To Check the "Toe-in."

One method is shown in fig. 3. Jack up front axle. Make a center line on each tire as wheels revolve. Then measure the distance from one line to the other. A straight stick with uprights can be used as shown in fig. 3. The measurement should be made at points about where the tops of the upright are shown in the illustration and this distance should be about ¼ to ⅜ inch less in front than rear, as at A, fig. 4. Another method (and one that is more accurate) is shown in the illustration to the left.

Keep Spring Clips Tight.

It is well to notice the spring clips occasionally, especially when car is new. In fact it is a good idea to tighten bolts holding spring clips about every 500 miles of running. A loose spring clip will often cause a mis-alignment.

Why Tires Wear Unevenly.

Quite often, when front tire has a worn place around tread, it is due to mis-alignment. Why a right rear tire wears faster than others is due to the crown of the road being oval, also because most of the driving is done on the right side, the weight is thrown more on that side.

Dodge front wheels should "toe-in" ⅜", measured on felloe of wheels level with hub.

HART 279—Alignment of Wheels. Excessive tire wear is often caused by improper alignment.

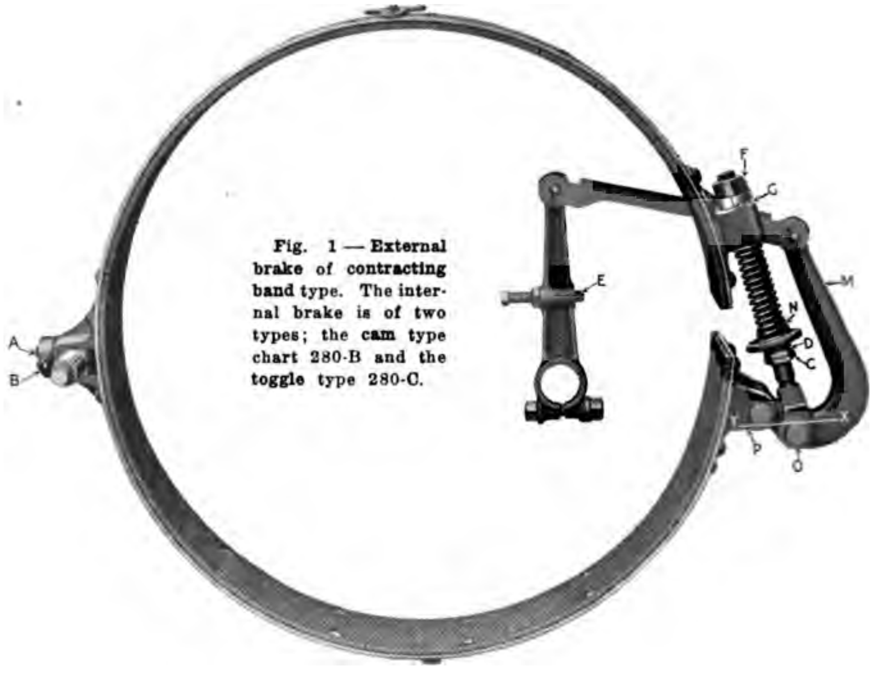


Fig. 1 — External brake of contracting band type. The internal brake is of two types; the cam type chart 280-B and the toggle type 280-C.

Brake Troubles—the Cause.

When brakes will not hold it doesn't necessarily mean that the bands need adjusting. Oil or grease may cover the friction surfaces. Before jumping at the conclusion that the bands need new linings take off the wheels and examine the asbestos. If lubricant has saturated the linings, wash off the grease with gasoline or kerosene.

As brake linings wear it becomes desirable to adjust the brakes in order to get that perfect action so necessary to safety and satisfactory service.

Adjusting brake rods: Failure of the brakes to hold as securely as is desirable—note this fact carefully—may be due to insufficient **forward** travel of the rods connecting the brakes with the foot pedal or hand lever.

Dragging may be due to insufficient backward travel. **The remedy** for either of these troubles should first be sought by lengthening or shortening the rods. Until after this is done no adjustments should be made in the brakes themselves.

External Brake Adjustments.

First of all put jacks under the rear axle, being careful to have them press up against the housing proper (or on some Timken axles, against the pads made for this purpose), but never against the truss rods. Raise both rear wheels off the ground.

Next, put all the brakes on both sides of the car in a complete "off" position.

Before making any adjustments of the brake make sure that stop-screw (E) is so adjusted against the housing that the clearance between lever (M) and the support indicated by circle (N) is about $\frac{1}{16}$th inch when the brake is in "off" position. If no stop-screw (E) is used, accomplish the same purpose by lengthening or shortening the brake rod.

It is very important to make the following adjustments in such manner and degree that when completed and the brake is applied full force, the imaginary line X—Y running over pin (O) and under pin (P) will stand about as shown in the illustration (figure 1). This is necessary to insure proper toggle action by lever (M).

Begin at the rear of the brake by removing cotter-pin (B—fig. 1) and turning the adjusting screw (A) until the clearance between the drum and the brake band lining at this point is the least possible without the drum touching when it revolves. Try $\frac{1}{64}$th inch clearance to start and increase it if necessary only enough to allow all parts of the drum to clear as it revolves. Then replace cotter-pin (B).

We are now ready to adjust the lower half of the brake band. Loosen jam-nut (C) and turn stop-nut (D) up or down on the stem until all parts of the drum just clear the brake band lining say about $\frac{1}{64}$th of an inch. When this proper clearance has been obtained turn jam-nut (C) tightly against stop-nut (D) to lock it.

Now for the upper half of the brake band. Get the same bare clearance all around the drum by turning nut (F) being sure that it is always turned to a place where the groove (G) (in its under surface) fully engages the rib on the top of the fitting, thus automatically locking the adjustment.

CHART NO. 280—Adjusting Brakes—Timken as an example. External contracting band type.

—continued from page 681.

inaccessible universal joints it will be safer for the amateur to merely renew the grease without attempting to disassemble the housing. (see page 580.)

Should a knock or rattle develop, it is a case of disassembling and rebushing the joint. Quite often it pays to order a new part rather than repair it.

*Brake Adjustment, Care and Repair.

The brake mechanism of a car is divided into three general classifications as follows: —(1) external contracting band; (2) internal expanding band; (3) internal expanding shoe.

The operation of the brake mechanism on or in the brake drums, is divided into 4 classifications; (1) external contracting band by a fulcrum arrangement to draw the band tight around the drum; (2) internal expanding band, expanded by a "cam" arrangement as per chart 280-A; (3) internal expanding band, expanded by a "toggle" joint arrangement as per chart 280-B; (4) internal expanding shoe, (usually of metal, similar to fig. 2, below) operated by a "cam" arrangement.

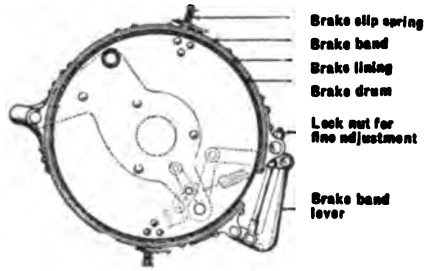


Fig. 1—Names of parts of the external contracting band brakes (Overland).

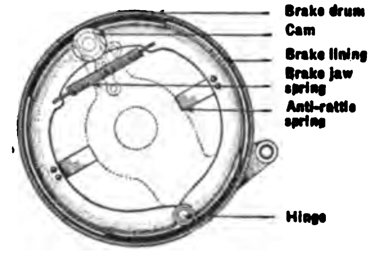


Fig. 2—Names of the parts of the internal expanding shoe (metal) brake, hinged type. The shoe on this brake is lined with fabric, but sometimes we find this shoe without lining and made of bronze.

The external brake is operated, usually by a **foot pedal and is called the foot brake.**

The internal brake is operated usually by a hand lever and is called the **hand brake**—formerly known as the emergency brake—see pages 28 to 30. Sometimes a brake pulley is mounted on the external part of the transmission shaft and connects with the hand lever, it is then called the **transmission brake**, but is usually operated by the hand lever, therefore it would also be termed the hand brake.

The band brake is the most popular—for both internal and external use.

Where metal to metal brakes are used a constant and extravagant supply of oil is required to prevent excessive wear. The inconvenience and uncertainly of lubrication together with the cost of renewing the expensive brake shoes, rendered this type of brake unsatisfactory.

The ideal brake lining then is one in which the co-efficient of friction is maximum and the deterioration due to heat is minimum. A special treated asbestos is the only material today of which such a brake lining can be made. Asbestos is a fibrous mineral; a natural rock, heatproof and will stand considerable usage without excessive wear.

Care of Brakes.

As the safety of a car depends on its brakes, they must be kept in the best possible condition. They should bind tightly when pressure is applied to them, and be free and clear when the pedal or lever is released. A brake band or shoe that binds when the pressure is released, produces friction and makes the car hard running.

Slipping of brakes is caused by either poor adjustment, *oil between the surface, or worn linings. The first may be cured by readjustment. In the second case, wash out the oil with a little gasoline and then stop the leakage of grease out the rear axle.

Slipping caused by worn linings may be remedied to some extent by taking up the adjustment, but if too much worn for this they must be replaced. Replacing the worn lining is not difficult, as the leather or fibre is held to the steel band by copper rivets. Replace with others to hold the new lining.

Because the application of the brake generates heat, leather linings will be burned if kept in contact too long. For this reason, the brakes are usually lined with fabric, called raybestos or multibestos.

If when applying the brakes, the car has a tendency to skid to one side, this indicates that one wheel is free and other dragging. Brakes are not equalized in adjustment. Therefore the brake resistance should be equalized.

The operator can save considerable on his brakes if applied gradually. For instance, if a stop is to be made, instead of dashing up to the stop and applying the brakes with full force suddenly, simply coast to the stop and gradually apply the brakes or not at all. This of course, requires practice.

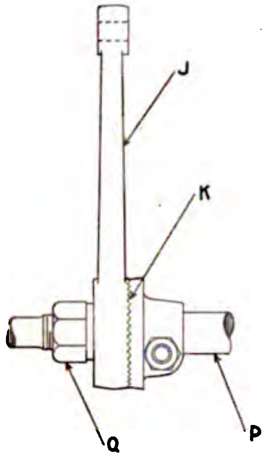
If a brake squeaks it is dirty and needs cleaning by removing and cleaning with a stiff brush and gasoline. The dirt clogs the pores in the surface of the lining and glazes it over, which causes the squeak.

Lubrication of brakes: While asbestos lining requires practically no lubrication on account of its high resistance to heat, it is advisable to apply a few drops of thin oil to the brake shoes or bands occasionally, or about every 2000 miles. This maintains a smooth surface on the brake drum.

See that hinges, cams, toggles and lever bearing are kept well supplied with oil. If an external contracting brake should chatter, apply three or four drops of oil to the friction surfaces. **Cleaning brakes**—see page 688.

—continued on page 691.

***A common brake trouble is slipping**—due generally to oil or grease working out of the rear axle. Therefore the first and most important point is to stop this leak by putting in a washer—see page 678.



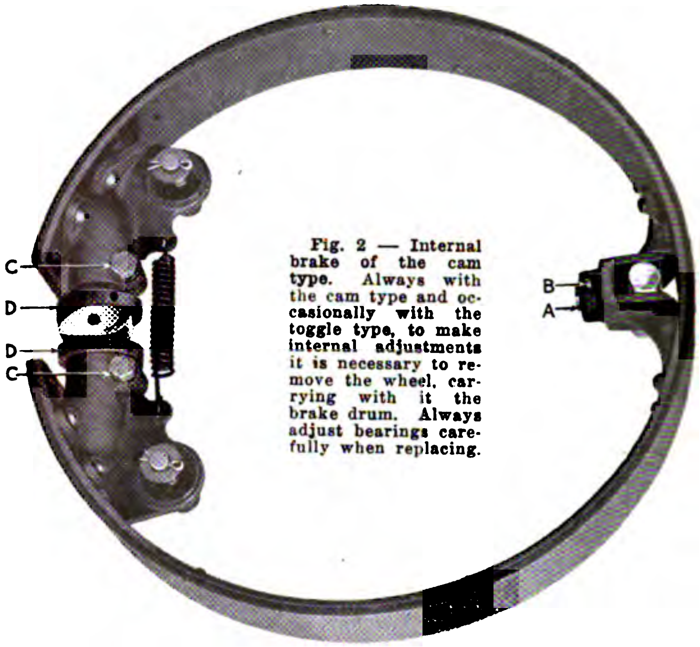


Fig. 2 — Internal brake of the cam type. Always with the cam type and occasionally with the toggle type, to make internal adjustments it is necessary to remove the wheel, carrying with it the brake drum. Always adjust bearings carefully when replacing.

Adjusting Timken Cam Type Brake—(internal).

Slight wear of the brake band lining ordinarily can be taken up without getting into the brake proper. This is done by loosening nut (Q) and moving lever (J) forward one notch in ratchet (K), then tighten nut (Q)—perhaps two notches forward may be required.

For more band lining wear—put jacks under rear axle, being careful to have them press up against the housing proper (or, on some Timken axles, against the pads made for the purpose,) but never against the truss rods. Raise both rear wheels off the ground.

Next; put all the brakes on both sides of the car in a complete "off" position.

If the adjustment is merely to take up for wear of the brake lining in service it is only necessary to (1) remove the wheel which also removes the brake drum; (2) remove cotter-pin (B), give adjusting screw (A) two turns to the right (i. e., in a clockwise direction) and replace pin (B); (3) loosen screws (CC), give cam plates (DD)) one-half turn outward (i. e., to the left or contra-clockwise) and tighten screws (CC). Put the wheel back on and try the brake in "off" position for a bare yet sure clearance so it will not drag. Try it in the "on" position for holding power.

If greater clearance is required—remove the wheel and partially reverse the adjustments detailed in the preceding paragraph.

If still more holding power is desired and there is some clearance yet to spare in the "off" position—remove the wheel and repeat the adjustments to a partial extent.

When more elaborate adjustments are required, than are required when merely compensating for wear of the lining—it is best to use a dummy or skeleton drum, that is, one with parts of its outer flat surface cut away to give ready access to the interior.

Garage men who have enough of such work to warrant it usually have, or can obtain from the Timken Co., Detroit, Michigan, a dummy drum. It is a great time saver. But by removing and replacing the wheel a few times the same result can be obtained by "cut and try" and the following directions based on the possession of such drum will be a true guide to that method as well:

Adjustment when using dummy drum: With both rear wheels off the ground and all the brakes on both sides of the car in a complete "off" position remove the wheel and insert the dummy drum in the place occupied by the drum on the wheel just removed.

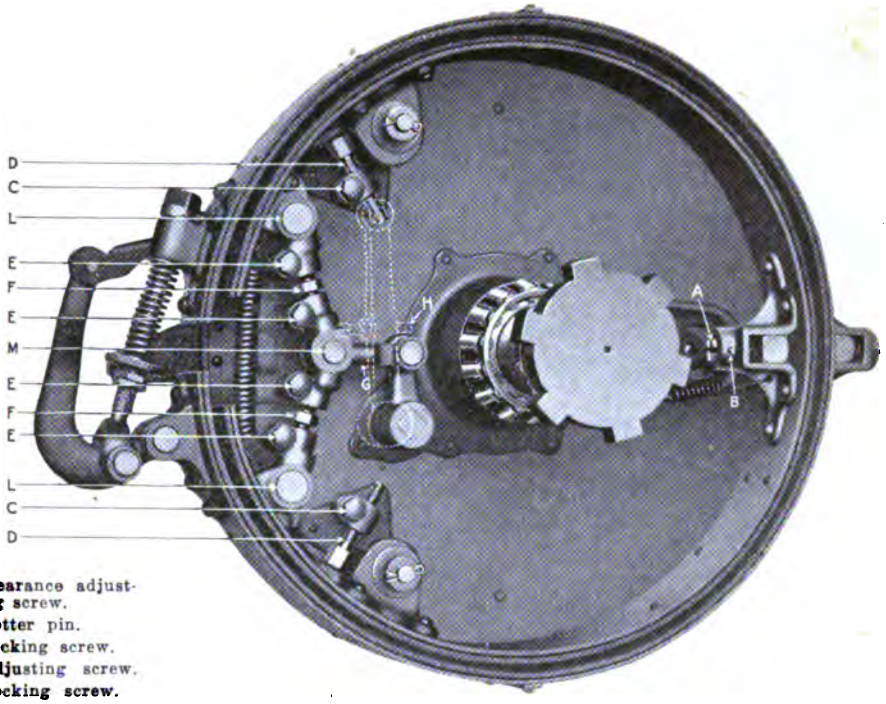
Begin at the rear of the brake by removing cotter-pin (B). Turn screw (A) in or out until the clearance between the drum and the brake band lining at this point is the least possible without the drum touching when it revolves. Try 1/64th inch clearance to start and increase it if necessary only enough to allow all parts of the drum to clear as it revolves. Then replace cotter-pin (B).

Next adjust both upper and lower halves of the brake band by loosening screws (C C) and turning plates (D D) in or out until all parts of the brake band lining just clear the drum by about 1/64th of an inch. Then tighten screws (C C).

To determine whether the brake band lining bears against the drum all around set the brakes, not too tight, and feel for any openings between the drum and the brake band lining with a thin piece of metal. Do this from the inner side of the drum. After completing these adjustments of the brake band turn cam-shaft (P) with your hands (top of shaft forward) until the brake band lining barely clears the drum, allowing the wheel to turn freely. With the driver's foot pedal or hand operating lever in "off" position adjust the length of the brake-rod so that lever (J) will stand in a nearly vertical position (leaning slightly backward).

Then tighten nut (Q). In replacing the wheel be sure to properly adjust the Timken bearings.

CHART NO. 280-A—Adjusting Timken Brakes—Continued — Internal expanding band — "Cam" type.



A—Clearance adjusting screw.
B—Cotter pin.
C—Locking screw.
D—Adjusting screw.
E—Locking screw.
F—Toggle adjusting screw.
G—Connecting link.
H—Stop screw.
L—Fulcrum pin.
M—Toggle pin.

Fig. 3—Timken internal expanding band operated by a "toggle" mechanism; this type is equipped with a triangular covered opening in the flat part outer surface of drum—through which adjustments can be made without removing wheel. In extreme cases—a dummy brake drum can be used, as explained in chart 280-A, which of course saves time. These directions explain the adjustments with or without the use of the dummy.

Adjusting the Timken "Toggle" Type Brake—(Internal).

First of all put jacks under the rear axle, being careful to have them press up against the housing proper (or, on some Timken axles, against the pads made for this purpose), but never against the truss rods. Raise both rear wheels off the ground.

Next, put all the brakes on both sides of the car in a complete "off" position.

Begin at the rear by removing cotter-pin "B," turn screw (A) in or out until the clearance between the drum and the brake band lining at this point is the least possible without the drum touching when it revolves. Try 1/64th inch and increase it if necessary only enough to allow all parts of the drum to clear as it revolves. Then replace cotter-pin (B).

Timken tapered cone type roller bearing. Used for wheel bearings, axle bearings and different parts of the car, see pages 673 and 674 of Timken axles—showing use in connection with axle parts. The part to the left is a case hardened steel race in which the roller friction is applied. Note also the inner race. (see page 86 for other types.)

Next adjust both upper and lower halves of the brake band by loosening (CC) and turning screws (DD) in or out until all parts of the brakeband lining just clear the drum by about 1/64th of an inch. Then tighten screws (CC) to lock the adjustment.

Next adjust the toggle so that a straight line touching the rear of the heads of pins (LL) will just touch the front of pin M. Loosen screws (EEEE) and turn screws (FF) until the forward edge of pin (M) is barely visible under any short, thin straight-edge laid against the rear of the head of pins (LL.) When this is true tighten screws (EEEE).

Adjusting a Timken Bearing.

To adjust Timken bearing—turn the bearing up tight, and revolve the wheel a few times by hand, which overcomes any tendency to back-lash. Then back off the adjusting nut very slightly, so that grasping the two spokes in a perpendicular line—one above and one below the hub—you begin to feel a very slight shake in the wheel. If this is more than barely perceptible, it is too much; and the adjusting-nut should be a little tighter. When you have it just right, lock it, and the bearings will give the best of service.

CHART NO. 280-B—Adjusting Timken Brakes—Continued—Internal expanding band—"Toggl type. **Timken Roller Bearing Adjustment.**

Overhauling Brakes.

There are three things which must be particularly noticed in taking care of brakes and putting them in condition:

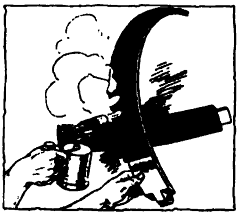


Fig. 1—Removing grease from under fabric.

(1) There must be no grease on the shoes; (2) The **fabric** must be in the best of condition; (3) The brake linkage **must** apply the brakes when pedal is depressed.

The grease: The grease which penterates to the brake **lining** usually works its way from the differential and can be **stopped by** renewing the washer in wheel hub.

To remove grease, first remove wheel, then inspect brake **lining** and see if it will come under head of No. 1 or No. 2 in the **list** above.

If a coating of grease is over the surface of the fabric there **will** be two methods of procedure. The first method for **removing** grease is by the application of gasoline. This removes the **grease** from the outer surface very well but not from below the **surface** of the fabric. A blow pipe torch can be used in this **instance,** which can be gently applied as shown in fig. 1, being **careful to** not char the fabric.

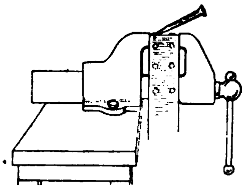


Fig. 2—Method of cutting rivets on worn band.

After the heat has been directed against the surface of the **brake for** a short length of time it will be noted that the grease will literally **fry out** of the fabric, leaving it upon the surface in the form of a **black carbonaceous** deposit. In this state it is readily removed by a cloth steeped in **gasoline.** The surface of the brake will now be in good condition if the **lining** has not been worn out.

If brake lining is badly worn down so far that fabric lining **is** too thin to be of service, then a new brake lining must be applied.

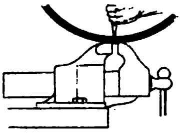


Fig. 3—Punch the cut rivets out.

Relining Band Brakes.

To reline the external brake: First, jack up rear wheels. **Disconnect** the levers, etc. from the brake bands and remove **wheels** and bands, being careful to keep all parts separate so they **can be** replaced with ease.

Second; wash all parts in gasoline, or kerosene to remove **grease** and dirt.

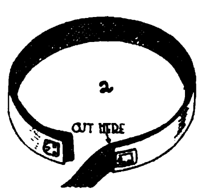


Fig. 4—Method of determining length.

Third, remove old brake lining, by placing band in a **vise and** cut the rivets with a chisel, fig. 2, then open up the bench **vise** about ½ inch, setting the bands so that the old rivets come **over** the opening one at a time, drive them out with a nail set, **fig. 3.** As the heads will most likely be worn off, it is easier to **drive** them from the lining side through to the band side. The old **lining** can then be easily removed from band.

Measuring: It is best to secure the lining from the **automobile** dealer or manufacturer ready to apply, but **if** this is not **possible,** then proceed as follows: Lay a tape measure around the **outside** of the external brake band allowing for an over-lapping of **about** ½ inch at the edges of the band opening. Or place the lining **inside** of the band per fig. 4, or measure the length from the old **band.**

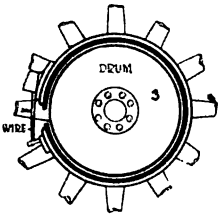


Fig. 5—Method for marking lining for hole.

In marking the lining for the holes, lay the wheel on a **bench or** the floor, hub side down, and putting the lining and band **in place** on the drum, as shown in fig. 5, wire the band so as to hold **it in** place correctly. With a pencil, using the holes in the band **as a** template, mark the lining. The holes can then be made by **using a** harness leather punch, or hand punch. **It is important that the holes be in the correct position** so that there is no slack **in lining** to form a hump. If too short it will lay uneven in the band.

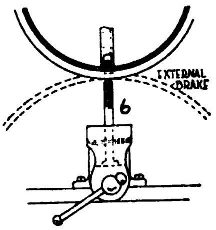


Fig. 6—Placing rivets.

Securing band to lining. With the aid of a few small bolts **and** nuts placed at intervals, secure the lining to the band in its **proper** position. **The next step is to countersink the holes so the rivet heads will be below the surface of the lining.** To do this properly one should use a countersinking tool made for such purpose, **as** shown in fig. 8, page 690, one can get good results however, **with a** wood screw countersink tool and a brace. If the latter is **used** it should be sharp or the lining will tear. Do not **countersink too** deep, just enough to permit rivet heads to be below lining **surface.**

—continued on page 689

HART NO. 280C—Overhauling Brakes. Relining Brakes.

—continued from page 688.

To place rivets, see fig. 6, this shows a way of using a bolt held in a vise with the head of the bolt resting on the arm of the vise to give a solid foundation.

The illustration shows internal brake curved up and external brake curved down. The rivet head goes next to fabric and riveting always done on the band side.

Insert a rivet through the lining and band as in fig. 6, the head of the rivet resting on the bolt, draw the rivet snug with a rivet set, or short piece of small gas pipe. Two or three blows with a hammer will be enough to draw the rivet head and lining tight and in place, too much pounding is very bad as well as unnecessary as it will tend to draw the rivet deeper in the lining and perhaps weaken it to the point of breaking through. Not over 3/16 in. should protrude through band.

To rivet: Still holding the band in the same position, the projecting or the hollow end of the rivet is peined down with the ball pein of the hammer till a good head is formed and the rivet draws tight.

When riveting the external brake, start at one end and work to the other, being sure the lining fits tight, otherwise there will be humps. A method employed by many repairmen to get band tight is shown in fig. 7, page 690.

The riveting is started at the center on the internal brake, working out from the center on both sides and stretching as the work proceeds. Any surplus lining which extends beyong the bands after the riveting is completed is cut off flush.

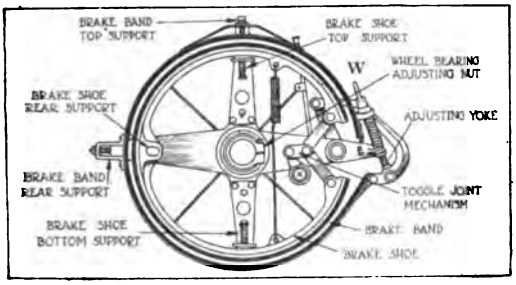
The rivets used are of soft brass with cupped head and hollow end and can be supplied by accessory houses.

Do not remove the bolts that were used as temporary holding until the holes not occupied by bolts have been filled with rivets. This will complete the foot brake and the same methods are used in relining the internal or hand brake.

If brake is of the metal to metal type then it is a matter of adjustment.

Relining Brakes on Dodge.

Operation: (1) Jack up rear wheels; (2) remove wheel flanges; (3) remove wheel bearing adj. nut; (4) remove wheel and brake band; (5) wash brake bands; (6) remove old brake lining; (7) rivet new lining bands; (8) replace brake bands; (9) put wheel on; (10) replace and adjust wheel bearing adj. nut; (11) replace wheel flanges; (13) adjust brakes.



Adjusting Dodge Brakes.

External brake is connected with foot brake pedal: Adjust the hex check-nuts on the lower part of the adjusting yoke, as well as the wing nut (W) at the top, in order that the band may be taken up as much at the bottom as the top.

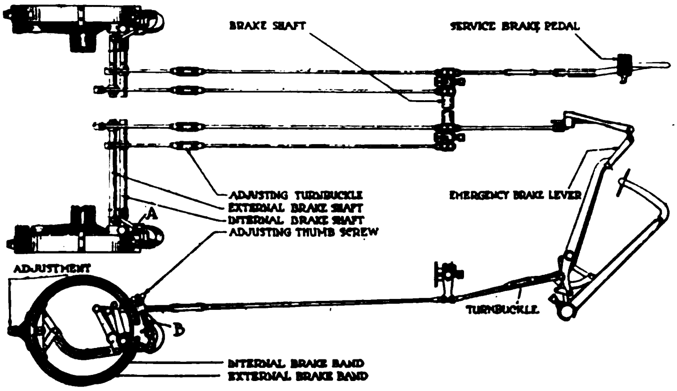
See that the "brake-supports" are adjusted so that the brake band takes hold evenly all the way around and does not drag when released.

To adjust the internal brakes, take up on front end of pull rod.

Material required for a Dodge brake relining job; 88 in. lining 2¼x3/16 inch for external brakes; 71 in. lining 2x3/16 inch for two internal brakes; 12 steel cotter pins 3/32x¾ inch; 80 brass rivets 3/16 in. long, ⅛ in. di., ¼ in. head.

Adjusting Brakes on Buick Light Six.

The internal and external brakes are steel bands lined with friction fabric. The foot brake pedal connects with the external contracting band and the hand, or emergency brake lever connects with the internal band.



Adjustment of the foot or service brake: (1), adjust rear support screw leaving 1/16 in. clearance; (2), adjust bottom of band to drum to 1/16 in. clearance; (3), adjust top clearance same. A "thumb-screw" takes up top half of band and a "hex-nut" on lower part of it, takes up the lower half of band.

Adjustment of the hand or emergency brake: The adjustment can be made by shortening the rods with the turnbuckles.

IART NO. 280D—Relining Band Brakes. Dodge Brake. Buick Light Six Brake Adjustment.

Fig. 21—To force a one-piece clutch lining on a cone clutch, insert a rat-tail file in a bit brace. Force the lining on as far as it will go with the file, which should be a coarse one, and by turning the bit brace the file will roll the lining into place.

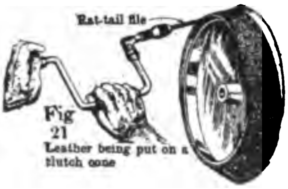
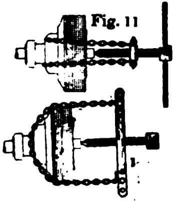
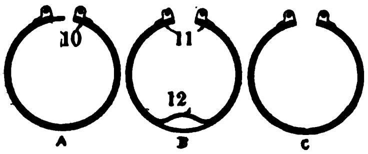

Rat-tail file
Fig 21
Leather being put on a clutch cone

Fig. 11—To remove a disk clutch that has a beveled back plate so that the usual arms of a crane puller will not take hold can be removed by using two short chains, one on each side of the shaft, back of the clutch. These are bolted together as close to the shaft as possible, bringing the free ends on each side of the clutch and over the puller arms, where they are again bolted together. Pins can be inserted in the arms to prevent the chains from sliding off.





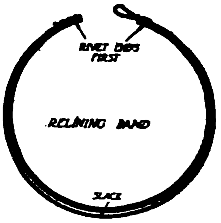


Fig. 7—When relining brakes some repairmen use the following method to get band tight. Rivet first at 10, then at 11. This leaves a slack which is drawn up when riveted at 12. This forces lining tight against band all way 'round if care is used in securing proper length.

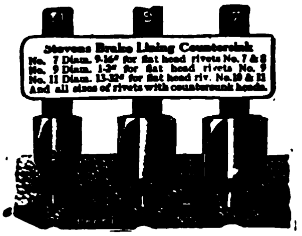

11
9
7
Stevens Brake Lining Countersink
No. 7 Diam. 9-16" for flat head rivets No. 7 & 8
No. 9 Diam. 1-2" for flat head rivets No. 9
No. 11 Diam. 13-32" for flat head riv. No. 10 & 11
And all sizes of rivets with countersunk heads.

Fig. 8—A brake lining countersink for flat head rivets 9/16, ½ and 13/32 inch. This device will countersink holes in any style of brake or clutch lining. Shank is 5/16 inch di. and works on a hand or power drill. (Stevens Co., 375 Broadway, N. Y.)

An anti-slip brake wafer is a handy thing to slip between brake drum and band when brakes slip—mfg'd by Armiger Chemical Co., 2255 Austin Ave., Chicago.

Torque arm repair—Figs. 1, 2 and 3 explain how a torque member on the Studebaker can be repaired when the wear cannot be taken up by simply tightening the nuts in place. The nuts and bolts are removed and holes drilled for oversize bolts. 7/16 inch bolts will do and are placed with heads in side in the two forward side holes only. The heads are dressed down. A better job will result if holes are first drilled slightly smaller and then reamed. A steel wedge piece, thickness slightly greater than the space between gearbox and torque arm fastened by a single rivet is used as shown in figs. 1 and 2. Drive torque arm on gear box and bolt in place.

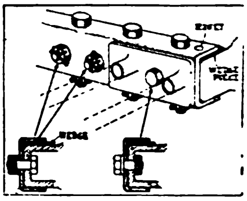


Fig. 1—Upper—How wedge is inserted inside of torque arm and held by rivet
Fig. 2—Lower—Section through torque arm showing wedge in place

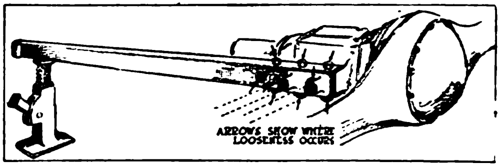


Fig. 3—Method of determining looseness in torque member

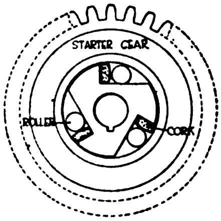


Fig. 9 — A starting motor clutch repair— (Hupmobile 32) After extended use, the starting clutch occasionally slips, or refuses to grab. This is usually caused by wear in the steel cylinders of the clutch dog.

By the following method the same cylinders may be used, and the clutch placed in satisfactory operation without the necessity of installing any new parts.

To do this it is only necessary to remove the starting clutch and gear, clean the parts and again assemble them. After the assembly, strips of cork, about ⅛ inch thick are inserted at the rear end of the clutch cylinder recess, in the manner shown in fig. 1. These hold the cylinders out, and cause them to engage properly. (Motor World.)

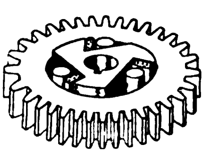


FIG 9
Roller starter clutch used on Hupmobile 32 showing how cork is inserted

Fig. 12. Steering Device Adjustment.

To adjust mesh of worm and gear—(Mitchell as example.) After removing clamp plate holding steering gear to frame, move up far enough to make accessible; take out spring retainer "C" and turn the eccentric bushing "B" until proper mesh is obtained.

If, after the gears have become worn after long usage to such an extent that the adjustment will not prove satisfactory, the gear "D" can be turned one-half revolution and this will place the unworn part of the gear in mesh with the worm "E," saving the expense of renewing the complete gear When making this change it will be necessary to put a new notch in the corner, which becomes the top, so that the pinch bolt of the steering arm can be installed.

Remove steering wheel. Take off spark, throttle lever and quadrant, loosen the pinch screw in collar that sets down tight against steering wheel hub. Unscrew collar and by tapping at hub the steering wheel can be removed.

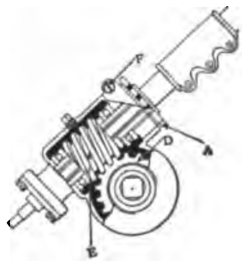


Fig. 12.

CHART No. 280-E—Miscellaneous Repairs and Adjustments. Brake Lining Countersinks.

Adjusting Brakes.

There are two types of brakes in general use, the internal expanding brake and the external contracting brake—see page 685.

Most of the brakes now in use are lined with brake lining or a kind of asbestos fabric.

Before starting to adjust the brakes, jack up the wheels and see if the bearings are tight, if loose, brakes will be out of line and bearings should be taken up.

Test brakes to see if band is badly worn. If so, a new lining will be needed. Also see if the lining has worn down to such an extent that the rivets have cut the brake drum—if so, then the wheel must be removed and the brake drum smoothed down with emery cloth, or in bad cases turned true and even on a lathe. If band is not entirely worn down then the brake band can be adjusted for clearance.

Clearance adjustment of the external brakes is very important. If the band touches the brakes at different points of its circumference then the brake will drag at that point, which of course, consumes extra power and wear on the lining. The purpose of adjusting this clearance is to relieve the drag or to take up on an excess of clearance due to wear of lining.

The proper clearance on most brakes is about 1/64 to 1/16 inch all 'round. Usually this clearance can be taken up by loosening the lock nut O, page 684 and tightening up the nut (D). This ordinarily is sufficient. If however, the clearance is more or less at the rear, then the clearance can be adjusted at A and B. The top half of brake can be adjusted by screw (F). However, the top half of brake is always given slightly more clearance than the bottom because the drum revolving in a right hand direction has a tendency to draw the top half of band to the drum.

If the brake drags at any other point in its circumference, then a large screw driver can be wedged between brake band and drum and by slightly hammering on each side of the band the clearance can be gained, together with adjustment of the adjustment screws and nuts.

Many repairmen adjust brakes with wheels on the ground and after making adjustment, car is moved backward and forward to see if band drags and be sure that both brakes are adjusted equally.

To adjust the internal brake, see pages 686 and 687. Ordinarily the adjustment is made by taking up on the pull rods.

Don't forget to oil all the levers and joints connected to the brake after making adjustment.

The foot brake requires more adjustment because it is used most. **The hand brake** is mostly used for locking the wheels when standing and at intervals in conjunction with foot brake on steep hills, therefore it requires less attention.

Brake Pedal Adjustment.

Sit in the driver's seat and test the pedal to determine if it is in the correct position for proper braking tension when brake pedal is applied. If not, it should be adjusted by movement of turnbuckle, per page 689. The lever (M), page 684 should be in toward the band in order to allow for full leverage.

Brake Lining—Size and Price.

There are several good brands of brake lining on the market. For instance Multibestos, Raybestos, etc.

The sizes are usually measured in thickness and width and sold by the length, per foot.

The thicknesses run from ⅛, 5/32, 3/16, ¼ and 5/16 inch. The **widths** run from 1, 1¼, 1½, 1¾ on up to 6 inches wide. The **price** varies from 33c per foot to $3.60 per foot. The **Ford** uses 1⅛x5/16 and sells for 40c per foot.

**Steering Gear Adjustments.

There are three general used types of steering gears; the worm and nut (see Jacox, chart 281); the worm and wheel (Warner); and the bevel type, fig. 7, chart 281.

Taking the simplest first (fig. 7) **the bevel type** requires very little care and what there is, is so evident to anyone who will look at the device that there is little need of description.

Enough to say that the oil cups which lubricate the pinion bearing and the steering arm bearing (B) should have their due attention. A filling at least once in two months and preferably twice that often. There is generally an adjustment just above the pinion bearing with which all lost motion can be taken up.

In the worm and wheel type, there are generally two adjustments, one which operates on the worm, the tightening of which eliminates up and down motion of the worm, and the other in the form of an eccentric bushing which supports the steering arm and wheel.

The first mentioned adjustment is generally a nut on top of the steering gear housing. By screwing the nut down the thrust bearings are brought together and up and down motion is removed. The eccentric bushing, which is generally held in adjustment by a locking bolt, permits the wheel to be turned farther into the worm, thus giving a closer engagement of the teeth and taking up the lost motion.

Any steering gear is difficult to lubricate, and furthermore, requires more lubrication than is generally appreciated. The difficulty in oiling is that there is practically no pumping action. As a result, the steering gear housing should be kept very nearly full of grease at all times. Some manufacturers recommend light transmission grease, others heavy graphite. Either lubricant will work well if it is kept packed in. This is important. Keep it packed in. Not enough grease means a partially dry worm.

The worm and nut type has one adjustment. This is in the form of a nut on top of the housing, locked with a locking bolt, which applies pressure to the nut by drawing together a slotted portion of the casting. **In this type there are two half** nuts which surround the worm. The adjustment removes up and down motion in these half nuts. When the adjustment cannot be made with the nut, the worm may be reversed and a new bearing surface will be created. This adjustment is not possible in all makes.

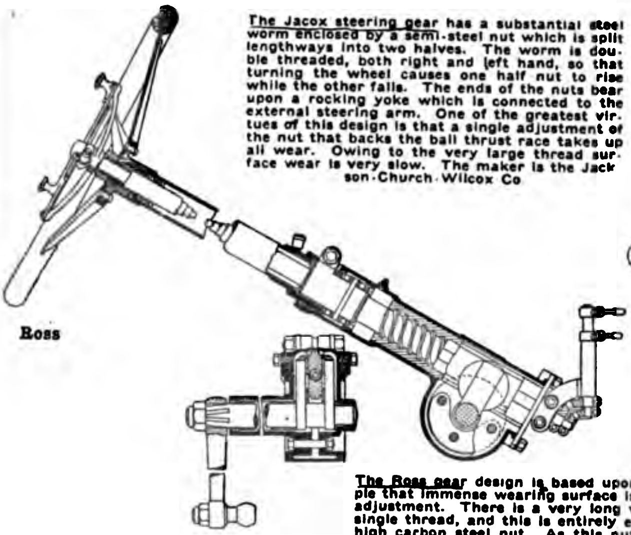
Limits of adjustment: Adjustments in all types, providing the wear is not excessive, allow adjustment from very nearly zero to a matter of 2 inches or more on the rim of the steering wheel. The writer does not recommend a certain amount of lost motion. It is a matter of driver's preference and steering gear makers themselves grant that no standard can be set.

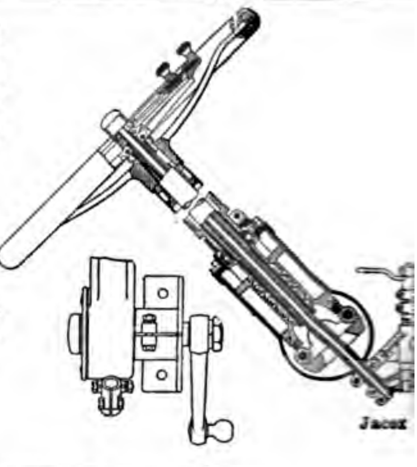
A very tight adjustment inflicts a strain on the driver, because the steering gear, being slightly reversible, transmits road shocks (which can easily be taken up by allowing a slight play in the steering assembly) to the driver's hands and arms. It **might be said that 1½ inches on the steering wheel is the average amount of play.** Too much play is dangerous however, when making quick turns.

---

*The Timken brake in three types are used as examples for adjusting brakes—as per charts 280, 280-A and 280-B. **See page 692 for address of steering gear manufacturers.

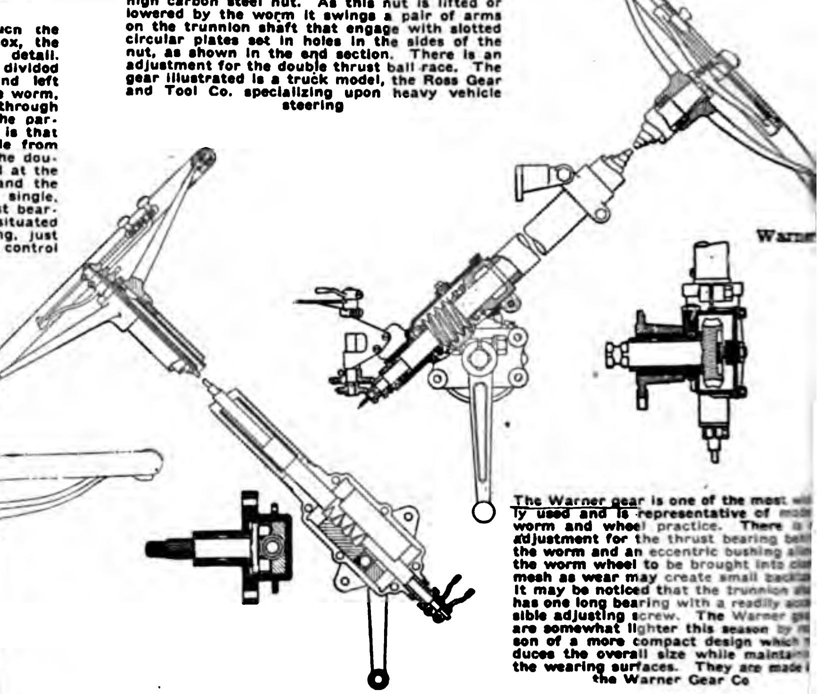
The Jacox steering gear has a substantial steel worm enclosed by a semi-steel nut which is split lengthways into two halves. The worm is double threaded, both right and left hand, so that turning the wheel causes one half nut to rise while the other falls. The ends of the nuts bear upon a rocking yoke which is connected to the external steering arm. One of the greatest virtues of this design is that a single adjustment of the nut that backs the ball thrust race takes up all wear. Owing to the very large thread surface wear is very slow. The maker is the Jackson-Church-Wilcox Co

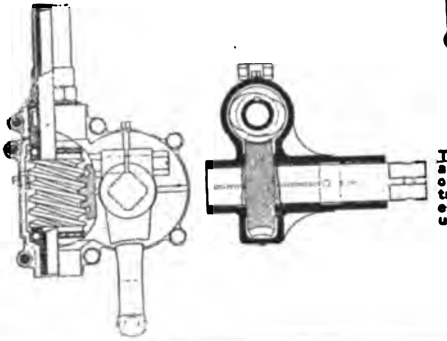




The Ross gear design is based upon the principle that immense wearing surface is better than adjustment. There is a very long worm with a single thread, and this is entirely enclosed by a high carbon steel nut. As this nut is lifted or lowered by the worm it swings a pair of arms on the trunnion shaft that engage with slotted circular plates set in holes in the sides of the nut, as shown in the end section. There is an adjustment for the double thrust ball race. The gear illustrated is a truck model, the Ross Gear and Tool Co. specializing upon heavy vehicle steering

The Lavine gear uses much the same principle as the Jacox, the difference being mainly in detail. That is to say there is a divided nut operating on right and left hand threads cut in a single worm, operating the steering arm through a rocking arrangement. The particular feature of this gear is that every wearing part is made from heat-treated alloy steel. The double thrust bearing is located at the bottom of the gear case, and the adjustment consists of a single, simple setting for the thrust bearing. The adjusting nut is situated at the bottom of the casing, just above the lower ends of the control levers. Wooden distance pieces are employed to keep the control tubes apart and to prevent rattle. The splined end on the trunnion shaft allows the steering arm to be set in the position desired by the chassis maker. This gear is made by the Lavine Gear Co





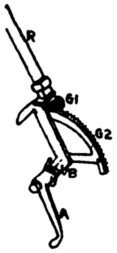


Fig. 7—Bevel type of steering device.

The Warner gear is one of the most wi ly used and is representative of mod worm and wheel practice. There is adjustment for the thrust bearing bet the worm and an eccentric bushing all the worm wheel to be brought into clo mesh as wear may create small backla It may be noticed that the trunnion sh has one long bearing with a readily acc sible adjusting screw. The Warner ge are somewhat lighter this season by re son of a more compact design which duces the overall size while maintain the wearing surfaces. They are made the Warner Gear Co

The Barnes gear is a worm and wheel pattern having adjustments, one back of the thrust bearing and the on the trunnion shaft bearings, the shaft being held in e tric bushings. The use of a full worm wheel and a end shaft allows the four quarters of the worm wheel used in turn, thus providing yet another increase of bility. This gear is made by the Barnes Gear Co.

HART NO. 281—Steering Devices—Types in General Use—see "Specifications of Leading Cars," pages 543 to 546, for types used on different cars. (Automobile.)

ldress of gear manufacturers: "Jacox," Jackson, Church Wilcox, Saginaw, Mich.; "Lavine," Lavine Gear icine, Wis.; "Warner," Warner Gear Co., Muncie, Ind.; "Ross," Ross Gear & Tool Co., La Fayette, Barnes," Barnes Gear Co., Oswego, N. Y.; "Gemmer," Gemmer Mfg. Co., Detroit, Mich.

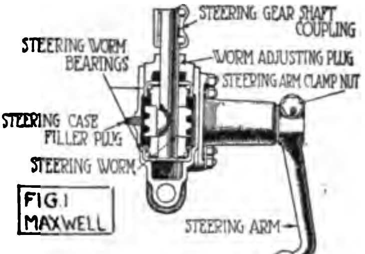


FIG. 1 MAXWELL

Sectional sketch of Maxwell steering gear. Oil is inserted through a pipe plug.

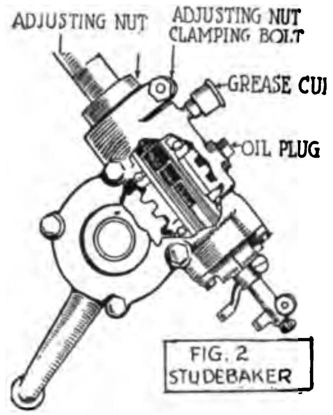


FIG. 2 STUDEBAKER

Cut-away view of Studebaker steering gear showing adjustable feature

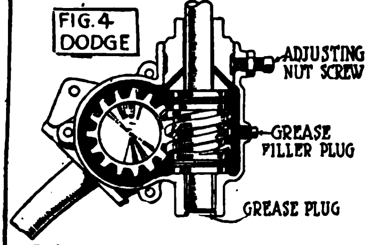


FIG. 4 DODGE

Dodge steering gear showing adjustment and method of oiling

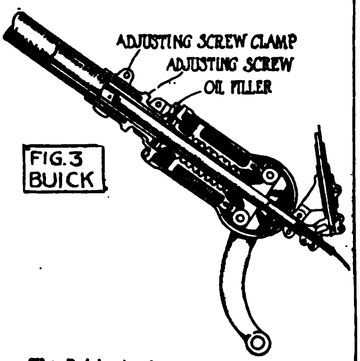


FIG. 3 BUICK

The Buick steering gear is adjusted by turning down the nut on top of the housing

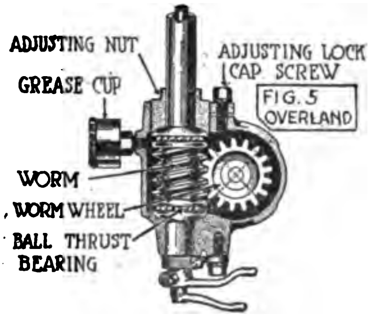


FIG. 5 OVERLAND

Parts in Overland steering gear which need care

Maxwell Steering Gear.

Maxwell steering gear is of the worm and wheel type and has two adjustments.

If an excessive amount of end play or lost motion exists, remove the two upper bolts in the steering-gear shaft coupling and pull the steering wheel and shaft upwards. Then unscrew the steering arm clamp nut and remove the steering arm with the worm wheel shaft. The steering gear worm adjusting plug clamp screw should then be loosened and while turning the steering gear with a hand on the coupling about a quarter turn to the right and left, tighten the plug until the play is taken up.

If there is still lost motion in the steering wheel, remove the steering arm and turn the wheel until the steering arm clamp has rotated a quarter turn and replace the steering arm, thus giving the gear and worm a new bearing surface.

The steering gear filler plug on the side of the housing is for admission of soft cup grease and the easiest way to fill the housing with lubricant is to insert it with a grease gun.

Studebaker Steering Gear.

Studebaker steering gear—Provisions have been made for adjusting end play in the Studebaker steering column by turning the nut on top of the steering gear housing. Turning it down takes up the play.

In the steering gear housing there is located an oil plug, as shown in the illustration. By removing this plug grease can be forced into the housing with a grease gun. Grease should be put in about every 1,000 miles.

Directly above the plug is a grease cup which lubricates the worm-shaft bearings. Also at the end of the worm-wheel shaft there is another grease cup. This is directly outside of the frame. Each of these cups should be emptied every 1,000 miles of course being turned down at regular intervals.

Buick Steering Gear.

Buick steering gear—The steering screw is provided with a ball-thrust bearing at its upper end and an adjusting nut, by means of which lost motion may be taken up. For best results, the factory recommends that the steering wheel should not have over 1½ inches of lost motion in its rim. The adjusting nut is, of course, turned down to take up play.

An oil plug is provided in the gear housing and this housing should be kept constantly filled with very heavy flowing oil. There is a small oiler in the hub of the steering wheel which lubricates the upper bearing of the steering tube. A few drops of oil should be inserted here every 500 miles or so. The ball joints of the steering connecting rod should be kept packed with a soft cup grease, one cupful to be screwed down till empty, about every 500 miles.

Dodge Steering Gear.

Dodge steering gear—To take up end play in the worm shaft of the Dodge steering gear, loosen the gear shaft connection and the set screw and check nut on the adjusting nut at the top of the steering gear case. Then screw this adjusting nut down until all play is removed. Be careful not to tighten the nut so much that the steering gear will bind. Tighten all you have loosened, after the adjustment has been made.

To remove any play which may develop between the worm and the worm wheel, the adjusting plate of the worm wheel shaft eccentric bushing can be turned until the worm wheel is driven into closer mesh with the worm.

After much wear, further adjustment can be made by reversing the adjusting plate. After long usage, the steering-lever arm can be disconnected and the worm turned end for end and reinserted.

Pack the steering gear case with grease, (graphite grease is advised by the factory,) every 1,000 miles.

Overland Steering Gear.

To correct play in the steering gear, first jack up the front of the car so that the steering apparatus may be moved freely. Then loosen the two clamping bolts. Now turn the slotted adjusting nut to the right carefully to take up any slight amount of wear that may have developed in the ballthrust bearings, until the steering wheel no longer has any lost motion. Next turn the steering wheel hard around and adjust the worm gear by turning the eccentric bushing. Make this adjustment with the steering wheel turned to the extreme right and left, because the steering gear is bound to wear most in the center due to most of the car's travel being straight ahead.

After the bushing has been adjusted on several occasions and the play remains in spite of its adjustment, it will be necessary to remove the ball arm by first removing the clamping bolt. Then turn the steering wheel one and a half times around. This will present a new surface (there are four surfaces, as shown in illustration) to the gear. Make adjustment as before, of course, in replacing the ball arm.

CHART NO. 282—Adjusting the Steering Device of a Few of the Leading Cars—as an example. **(Motor Age.)**

Hudson Oiling Adjustments.

This subject is treated on pages 198 and 200. Additional matter is given below.

Evidence of Poor Adjustment.

1–Excessive and continued smoking at slow speeds. Sooty plugs.
This indicates that the central eccentric does not shorten the stroke of the pump sufficiently. Adjustment of control eccentric necessitated.

2–Oil pressure gage readings other than from ¾ to 1 lb. when idling or 2 to 2½ lbs. at high speed. Eccentric adjustment necessary, or a leak in the oil pipe lines.

3–Engine hot.
Dirty oiling system, necessitating cleaning and change of oil, with possible readjustment.

4–A pressure reading at slow speeds—none at high speeds.
Caused by the control cam permitting the plunger to work at slow speeds but stopping it at high speeds. Adjustment of cam necessary.
It is usually advisable to remove the oil pan, clean and refill with new oil in case of any oiling troubles before making any adjustments. A draining and replenishing of the oil supply is advisable every 1000 miles; or after the first 500 miles with a new car.

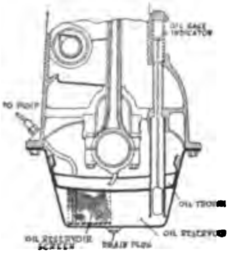


Fig. 1—The oil reservoir should be drained and cleaned about every 1000 miles. If the base be removed, always clean the screen When replacing base, have the oil trough full of oil, that the cranks may get oil from the start

To Clean the System.

1–Remove oil reservoir, drain plug and drain system.

2–Remove base.

3–Remove two bolts holding oil reservoir, screen in place, and wash with gasoline or kerosene

4–Wash oil troughs and reservoir with gasoline or kerosene.

5–Remove oil suction tube and see that it is open and clean. Blow out, if necessary.

6–Replace oil suction tubes and make all joints tight, otherwise the oil pump will draw air, preventing oil circulation and destroying the action of the pump.

7–Fill oil troughs with oil. Replace base.
If the oil troughs are not filled, the bearings etc., may not receive oil enough to prevent damage when starting the engine.

8–Refill the reservoir with new oil. This takes somewhat over 3 gals. and the indicator gage at the right of the engine should be about halfway up the column.

To Adjust Oil Pump.

1–Loosen throttle arm on pump-control eccentric at the right side of engine.

2–Turn control eccentric arm with a screwdriver until it is entirely free from plunger.
(This point can be determined when engine is idling by turning the screw (fig. 2) until a point is reached where the screw turns freely.)

3–It is then in the position shown in fig. 3, permitting the plunger to take full stroke under all conditions.

4–Speed engine up.

5–Note oil pressure. It should be about 2½ lbs.

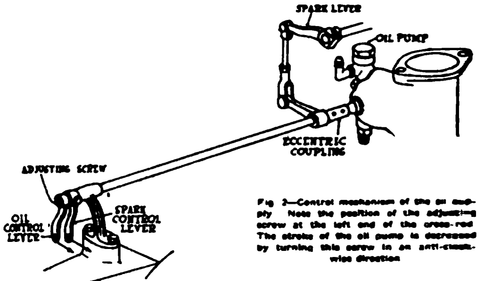


Fig 2—Control mechanism of the oil supply Note the position of the adjusting screw at the left end of the cross-rod The stroke of the oil pump is decreased by turning this screw in an anti-clockwise direction

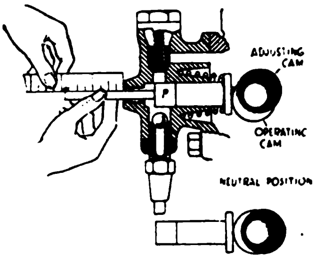


Fig 3—Left—Sectional view of the oil pump, showing method of measuring the stroke. With the engine idling, the stroke should be about 1/32 in.; when speeding, about 1/8 in. The small vertical spring at the top should be stretched or shortened until the oil pressure gage reads 2½ lbs., with the engine speeding, and the cam in the neutral position.

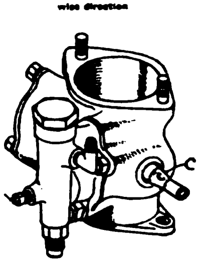


Fig. 4—Right—The letter C of the eccentric cross shaft should be just forward of the vertical, when the engine is speeding, in most cases of proper adjustment

6–If it is more than 2½ lbs. stop engine, remove oil valve spring, as shown in fig. 3, and stretch it slightly.

7–Replace spring and again test.

8–Should the gage read less than 2½ lbs., squeeze the spring shorter and test.

9–Couple up throttle lever as shown in fig. 2.

10–Start engine. Let it run with closed throttle.

11–Turn adjusting screw (fig. 2) in an anti-clockwise direction until the oil gage registers ¾ to 1 pound.

12–Lock throttle lever in place.

To Check Up Adjustment.

1–Remove plug, shown in fig. 3, and insert a match or nail in the hole, bringing it into contact with the plunger head. The pump can be felt going through its stroke. (Care must be taken in doing this, as the fan runs very close to the plug and offers opportunity for injury.)

2–When the engine is idling, with the throttle closed, the stroke of the plunger should be about 1/32 inch.

3–When racing, the plunger should have a stroke of about ⅛ inch.

4–With the throttle open the mark (C) on the control eccentric arm at the coupling should be just forward of the vertical (see fig. 4).
(In making any adjustment on the oil pump, always start with the control eccentric in the inoperative position and follow the steps through as outlined, otherwise the cam may be set in the wrong position.)

Principle of Operation of The "Ball and Spring" Oil Pressure Regulation.

The method of regulation of the pressure, where a ball check and spring is used is shown on pages 198, 200, 741. The ball and spring performs the same function as a safety valve on a steam boiler. It can be placed any where on the system (preferably farthest point away from oil pump). There are certain positions of crank shaft when no oil channels register and pressure would build up excessively high were it not provided with some means of release. When pressure exceeds that at which the regulating screw is set, it forces the ball off its seat and the oil passes through channel to lubricate the chains. If this regulating screw were set at too low a pressure, then all the oil would pass out under the ball and your crank pins would go dry. If set too high the oil feed would be too great and smoke, carbon and fouled plugs would be the result.

HART NO. 282-A—Adjusting Hudson Super-Six Oiling System—also see chart 99-A and page 200.

ee page 198, 200 and 741. (Motor World.)

INSTRUCTION No. 46-C.

HOW TO USE TOOLS AND MAKE REPAIRS: Screw Threads Explained. Taps; explanation and use of. Drills; how to sharpen and use. Tables giving Tap and Drill Sizes for S. A. E. and U. S. S. Screws. How to use Measuring Instruments; micrometers, gauges and machinists tools in general. Brazing. Welding. Soldering. Annealing and Case Hardening. Tube Bending. How to make Gaskets. Oxy-Acteylene Welding and Cutting. Repairing Broken Parts. Silent Chains; care and adjustment.

*How to Solder Aluminum.

The subject of soldering is treated in charts 289 and 290. Under this head we will treat on the subject of soldering aluminum.

There are various compounds on the market for soldering aluminum, but this operation depends more on the workman than on the solder, and unless considerable experience has been had it is probably better to purchase solder than to attempt making it.

Zinc can be used, but does not form a very strong joint. Tin can also be used, is more nearly the color of aluminum, is stronger than zinc, but is very difficult to work. A small proportion of phosphor tin added to pure tin makes it work more readily and is the basis of most aluminum solder.

The chief difficulty in soldering aluminum is that the heat is dissipated so rapidly that it cools the soldering iron, and furthermore, aluminum oxidizes instantly upon exposure to the air. This extremely thin film effectually prevents a perfect union being made. If the parts are well heated and melted solder kept melted by allowing the iron to stand on it, the surface can be scraped beneath the melted solder by the point of the soldering iron, thus preventing to a certain extent the oxidation. In this way the metal can be tinned.

When both parts to be brought together are well tinned, the parts can be united with some chance of success, nitrate of silver, resin, or zinc chloride being used as a flux.

A nickel soldering tool gives more satisfactory results than a copper one, as the latter alloys with the tin and soon becomes rough.

Cleaning the metal: If the surface is of such a shape that it cannot be readily cleaned by scraping, it can be cleaned by dipping it into a solution of nitric acid in three times its bulk of hot water containing about 5 per cent of commercial hydro-fluoric acid. This causes a slight action on the surface of the metal as shown by bubbles. Rinse the metal after removing from the acid bath and dry in hot sawdust.

Aluminum solder: The following formula, in the hands of a competent man, can be used to unite aluminum or aluminoid parts: tin, 10 parts; cadmium, 10 parts; zinc, 10 parts; lead, 1 part.

The parts to be united must be thoroughly cleaned and allowed to stand two or three hours in a strong solution of hypo-sulphate of soda before being operated upon, or cleaned in the acid bath described above.

***Methods of Case-Hardening.

Case-hardening of iron or steel is a process which causes the metal to absorb a certain amount of carbon so that the resulting mass will have a hard coating or case while the interior remains soft. The process varies and a great variety of carbonaceous substances are used for introducing the carbon into the metal. Solids are used more extensively than either liquids or gases for this work and some of the more common substances are charcoal obtained from wood or bone, charred leather, a mixture of barium carbonate and charcoal in the proportions of 40 to 60 per cent respectively, powdered bone, salt 10 per cent, charcoal 90 per cent, animal black, charcoal and potassium carbonate, potassium cyanide, etc.

Any of the compounds above may be obtained at wholesale drug houses. It would not pay to buy of the retail druggist. (see also page 696).

The extent of the hardening (that is, the thickness of the case), will be dependent upon three things, namely: the temperature of the part to be hardened, the time the

---

*See page 711. ***See page 696.

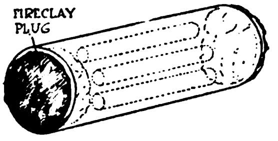


Fig. 1. Case hardening steel. The pieces are packed in a pipe with the hardening compound—but they must not touch.

*How to Case Harden Steel.

The outer surface of any piece of soft steel may be made hard by case hardening. Its purpose is to increase the strength and wearing qualities of the steel. All machine work to be done on the steel should be done before the case hardening, as grinding alone can be done afterward. (If any part of the piece must be left soft, this may be done by covering that part with asbestos paste or paper.)

The hardening compound: Mix 9½ parts of fine charcoal with 2½ parts of table salt. Place 2½ parts of kerosene oil in a dish, and put with it as much sawdust as is required to soak the kerosene up. Now mix the sawdust and oil with the charcoal and salt. This compound may be used many times.

The crucible: Get a piece of iron pipe long and large enough to hold the pieces to be hardened (fig. 1.) Pack the pieces in this pipe with the hardening compound. Do not let one piece touch another, or touch the pipe side, but keep them well apart with the compound. Now close both ends of the tube with fire clay.

A large forge fire is necessary for heating the pipe and the pipe should be heated to a bright red heat. The length of time varies depending on the size of the pieces, and the depth of case desired.

Ordinarily two hours at bright red heat will give $\frac{1}{16}$ inch case. This heat should be held as evenly as possible to give an even case and reduce warping effects.

To produce the maximum strength, two heat treatments are necessary after hardening. First heat each piece to a bright red and plunge in oil. Then again heat it to a dull red, and plunge. This will give a fine grain both in the core and in the case.

Quick Case hardening: If a thin case is desired, this may be applied quickly by heating the piece to redness and sprinkling the part to be hardened with potassium cyanide. Keep the temperature constant for 4 or 5 minutes, then plunge the piece in water or oil. An exceedingly thin case will result that will increase the wearing qualities of the steel, better its appearance and prevent rust.

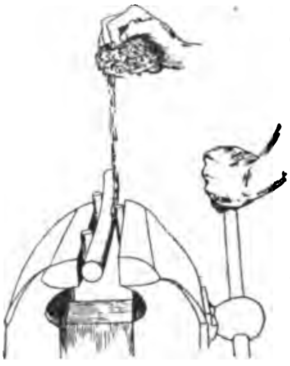
Another Method of Case Hardening.

It is possible to case-harden small pinions quite well by bringing them to a uniform bright-red heat and plunging them into finely-powdered yellow prussiate of potash, repeating the operation three or four times, and finally plunging into clean cold water whilst still at a red heat. The mild steel absorbs carbon from the potash to a depth of about $\frac{1}{60}$th of an inch, and this surface hardens perfectly on the final cooling. Nuts so treated resist rough usage with the spanner much better than an ordinary soft-surface nut.

In treating parts of this class it is, however, important to remember that the threaded part should be filled up with clay so that it does not come in contact with the carbonizing material; otherwise it will be certain to be spoiled. Any roughness of the surface, such as on the teeth of pinions, can be smoothed off with emery cloth wrapped over a thin flat file. Parts made from tool or high carbon steel, are readily hardened by making them red-hot and plunging them into cold water. The correct heat is important, because if the parts be heated to a very bright red, they may be spoiled or decarbonized, and if to a white heat, certainly so. On the other hand, if made barely red, the parts will not harden.

Straightening Warped Pieces.

Uneven heat and uneven cooling warps the steel. Case hardened pieces can not be straightened by pressure or by pounding as this cracks the case. **To straighten a warped piece of case hardened steel:**



1—Find the high or "bowed" part. Mark this with a chalk line.

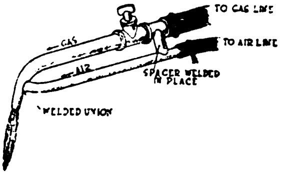
2—Heat the piece slightly—**never near a red heat.** (The amount of heat depends on the warp, and can only be determined by trial.)

3—Clamp the piece in a vise between the blocks as shown in fig. 2.

4—Direct stream of water at chalk line. This will contract the long side and make piece straight.

**A Home Made Gas Blow Torch.

Small soldering jobs, especially in cramped quarters, may be most readily done by means of a blowtorch. Such a torch may be made from pipe fittings in the manner illustrated. In brief, it comprises a piece of pipe, attached to the gas main by a length of rubber hose, with another piece of pipe, attached to the air line, and welded to the gas nozzle as shown. A spacer cross-brace is welded between the two pipes, at the rear, making the torch a unit. A valve on the gas pipe renders regulation of the flame easy. Though this torch is somewhat small for brazing jobs, a heavier torch could readily be made for that purpose—see also fig. 17, page 720, and 472.



†Gas Torch and Soldering Iron.

A—copper soldering iron. B—gas burner tube. C—gas burner. D—gas tube to connect hose.

This is a well-made tool. Can be used with illuminating or acetylene gas by attaching to gas burner or Prest-O-Lite tank with rubber tube. By removing the soldering iron the burner can be used as a blow pipe for brazing, also soldering aluminum — for sale by Auto Supply houses.

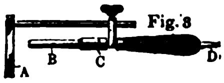
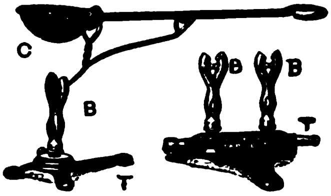


Fig. 3

Starretts Gas Heater.

The heater will be found very useful in the machine shop, as it is convenient for tempering small tools, heating soldering irons, melting lead, babbitt, etc., and as a forge for light work it will be found very valuable.

It consists of 1, 2, or 3 burners, with or without tool holder and is connected to the ordinary gas jet. A ladle 14 inches long, holding 12 ounces, can be had of the same Company. L. E. Starrett, Athol Mass.



Double Tube Gas Heaters

CHART NO. 282-B—How to Case Harden Steel. A Home Made Blow Torch. A Gas Heater. Straightening Warped Pieces. (Motor World.)

---

*See also pages 695-697. **See also page 472. †See page 735, 711 and 713 for gasoline blow pipe torches.

heated metal is in contact with the carbonaceous material and the kind of material used for producing the case. The usual case-hardening temperature is 1,650 degrees Fahr., but the higher the temperature the deeper will be the case. The article to be hardened is heated in a furnace and when a cherry red it is removed and imbedded in the hardening material. After removal it is sometimes customary to heat treat the case-hardened steel. This is done by reheating to about the same temperature or higher, if possible, and then quenching in water or oil. A second heating often is given but not as high as either of the others.

Tempering Drills and Small Tools.

Drills and small tools can be tempered quite well in a flame. Larger parts are better tempered on an iron plate on which has been placed a thick layer of fine sand and the flame allowed to play underneath. This ensures the part being uniformly tempered.

Temper-Colors of Steel.

Light Straw	430°
Straw	450°
Dark Straw	470°
Light Brown	490°
Dark Brown	510°
Light Purple	520°
Dark Purple	530°
Light Blue	550°
Blue	560°
Dark Blue	600°

The above will vary with the grade of steel, and the surface finish—as to whether it is rough or polished; and, in tempering tools, experience must be one's guide.

**Brazing.

Brazing is infinitely stronger than soldering. It is by brazing that bicycle frames are built up. Cycle makers use a gas blow flame. This consists of two parallel pipes— one for gas and one for air. The air, which issues under pressure, causes a strong and very hot flame. The air pressure is produced by a small bellows worked by the foot.

The hard solder, as it is sometimes called, is a brass that melts at a low, red heat. It is generally bought in packets, and is in grains about the size of a pin's head. Brass wire is also used. Being wound around the part to be brazed, it melts and runs into the joint. The flux used for brazing is powdered borax.

Accurate Measurements.

There is one feature of the motoring education that is rather neglected. Throughout this instruction reference is made to thousandths part of an inch and a little study along this particular line, will be time well spent.

Meaning of Thousandths Part of an Inch.

A thousandth part of an inch is infinitesimally small but it is used in measuring spark plug gaps, interrupter point gaps, on ignition contact breakers and also used in valve clearance, as per chart 228. By referring to page 541, full explanation is given.

How to determine the meaning and thickness of a thousandth part of an inch: For example. The decimals (.020") means, twenty thousandths part of an inch. If we divide an inch into one thousand parts, .020 would mean 20 of the parts or 20 one-thousandths of an inch.

By referring to chart 283-A reader will note a thickness gauge (fig. 4) which will enable one to measure any thickness from 4 to 25 thousandths of an inch. This paper is approximately 28 ten-thousandths of an inch thick and would be expressed in figures as .0028.

To read decimals — start with the first figure to the right of the decimal point which is tenths, the next figure is hundredths, next thousandths, next ten-thousandths, etc. The figures to the side of the decimal are read tens, hundreds, thousands, etc.

Thus the figure 3 standing alone, would represent (three units) but if it had a decimal point to the left of it as (.3) this would represent three tenths.

If expressed thus (.03) it would represent three hundreths and if expressed thus (.003) it would represent three thousandths and so on to any fractional part. (see page 541.)

By referring to chart 51, page 115 note how the decimals are converted or reduced to 64ths., thus .03 is equal to $\frac{1}{32}$ of an inch, .08 is equal to $\frac{5}{64}$ths of an inch, etc. Note—these figures are not mathematically correct, but are near enough for all practical purposes.

Use of Measuring Instruments.

This subject is treated in charts 283 to 284. Every car owner should at least possess an engineer's steel scale rule as per fig. 18, chart 284 which is divided into inches, and fractions of an inch, down to the 64th part of an inch.

The usual gradations on the inch side met with are thirty-seconds of an inch, though they may be obtained with finer graduations wherein the inch is divided into sixty-fourths, these latter divisions being about as fine as normal eyesight can read off. It is an advantage if such a scale is divided into tenths of an inch, as thereby, the user can initiate himself into the idea of decimal parts of an inch, hundredths and thousandths instead of eighths and sixteenths.

The writer would, however, recommend every car owner who wishes to be "au fait" with small measurements to buy a good make of sliding caliper or micrometer which will read in thousandths of an inch or with a **Vernier** attachment; in ten thousandths part of an inch. It is not at all an expensive instrument, and it provides a liberal education in the subject of measurements.

As has been stated it is difficult to judge sixty fourths of an inch on an ordinary scale, but nevertheless the vernier caliper enables thousandths of an inch to be read off quite easily with the unaided eye. The size of any part, even if it be as large as a piston, can be accurately determined at a glance.

The thickness gauge is another very useful instrument and is explained in chart 283-A, fig. 4.

**See also page 712.

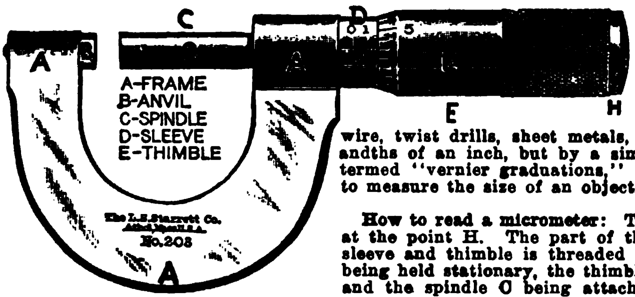


Fig. 6. The micrometer without a vernier scale. Above instrument designed for measuring outside, per fig. 3, page 649. See inside micrometer fig. 2, page 649.

The Micrometer.

Fig. 6: Is a measuring tool and used by machinists and others for measuring in thousandths part of an inch.

Its scope is a wide one, and it is regularly used for finding diameter of wire, twist drills, sheet metals, rods, etc. It ordinarily reads in thousandths of an inch, but by a simple set of graduations around the stem, termed "vernier graduations," after their inventor, it is easily possible to measure the size of an object, in ten thousandths of an inch.

How to read a micrometer: The spindle C is attached to the thimble E at the point H. The part of the spindle which is concealed within the sleeve and thimble is threaded to fit a nut in the frame A. The frame being held stationary, the thimble E is revolved by the thumb and finger, and the spindle C being attached to the thimble revolves with it, and moves through the nut in the frame, approaching or receding from the anvil B. The article to be measured is placed between the anvil B and the spindle C. The measurement of the opening between the anvil and the spindle is shown by the lines and figures on the sleeve D and the thimble E.

The pitch of the screw threads on the concealed part of the spindle is 40 to an inch. One complete revolution of the spindle therefore moves it longitudinally one fortieth (or twenty-five thousandths) of an inch. The sleeve D is marked with 40 lines to the inch, corresponding to the number of threads on the spindle.

When the micrometer is closed, the beveled edge of the thimble coincides with the line marked 0 on the sleeve, and the 0 line on the thimble agrees with the horizontal line on the sleeve.

Open the micrometer by revolving the thimble one full revolution, or until the 0 line on the thimble again coincides with the horizontal line on the sleeve; the distance between the anvil B and the spindle C is then 1/40 or (.025) of an inch. As there are 25 lines on the thimble, revolving it just one line opens the tool 1/25 of 1/40", which is one thousandth of an inch.

Each vertical line on the sleeve indicates a distance of 1/40 of an inch. Every fourth line is made longer than the others, and is numbered 0, 1, 2, 3, etc. Each numbered line indicates a distance of four times 1/40 of an inch, or one-tenth.

The beveled edge of the thimble (E) is marked in twenty-five divisions, and every fifth line is numbered, from 0 to 25.

Rotating the thimble from one of these marks to the next moves the spindle longitudinally 1/25 of twenty-five thousandths, or one thousandth of an inch. Rotating it two divisions indicates two thousandths, etc. Twenty-five divisions will indicate a complete revolution, .025 or 1/40 of an inch.

To read the micrometer, therefore, multiply the number of vertical divisions visible on the sleeve (D) by 25, and add the number of divisions on the bevel of the thimble (E), from 0 to the line which coincides with the horizontal line on the sleeve.

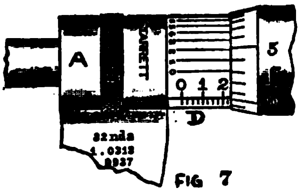


FIG 7

Fig. 7. Micrometer with a vernier scale. Showing micrometer open .2257 of an inch.

For example, as the tool is represented in the engraving, there are seven divisions visible on the sleeve. Multiply this number by 25, and add the number of divisions shown on the bevel of the thimble, (3). (7×25=175+3=178.) The micrometer is open one hundred and seventy-eight thousandths.

The Micrometer with a Vernier Scale.

Readings in ten thousandths of an inch are obtained by the use of a Vernier, so named from Pierre Vernier, who invented the device in 1631.

As applied to a micrometer this consists of ten divisions on the adjustable sleeve, which occupy the same space as nine divisions on the thimble.

The difference between the width of one of the ten spaces on the sleeve and one of the nine spaces on the thimble is therefore one-tenth of a space on the thimble (or one ten-thousandth of an inch).

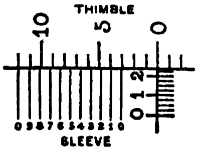


FIG 8

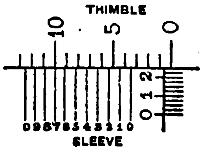


FIG 9

Fig. 8. Showing micrometer closed.
Fig. 9. Showing micrometer open .2257 of an inch.

In fig. 8 (which shows the scale as it appears when micrometer is closed), the third line from 0 on thimble coincides with the first line on the sleeve (note that the first and last lines on all verniers are designated by a zero. Line No. 1 is really the second line and line No. 2 is the third, etc.) The next two lines on thimble and sleeve do not coincide by one-tenth of a space on thimble; the next two, marked 5 and 2, are two-tenths of a space apart and so on.

In opening the tool, by turning the thimble to the left, each space on the thimble represents an opening of one-thousandth of an inch. If, therefore, the thimble be turned so that the lines marked 5 and 2 coincide, the caliper will be opened two-tenths of one-thousandth or two ten-thousandths.

Turning the thimble further, until the line 10 coincides with the line 7 on the sleeve as in fig. 9, the caliper has been opened seven ten-thousandths plus the amount shown on the sleeve (which in this instance has been opened 9 full revolutions). So 9x25 thousandths equals 225 thousandths, plus the 7 ten-thousandths, equals 2257 ten thousandths and the reading of the tool is .2257. Note—In reading a micrometer it is always necessary to multiply each division on the sleeve by 25 (as explained in fig. 6.)

To read a ten-thousandths micrometer, first note the thousandths as in the ordinary micrometer, then observe the line on the sleeve which coincides with a line on the thimble. If it is the second line, marked 1, add one ten-thousandth; if the third, marked 2, add two ten-thousandths, etc.

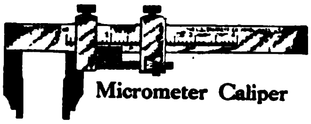


Fig. 12.

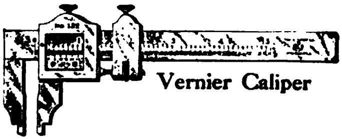


Fig. 13.

Calipers with Micrometer and Vernier Reading.

Fig. 12—A micrometer caliper similar in principle to a micrometer, but used for inside measurements as well as outside.

Fig. 13—A micrometer caliper with a Vernier attachment which renders it capable of reading in ten thousandths.

HART NO. 283—Micrometers—How to Read. A Vernier—Its Purpose.

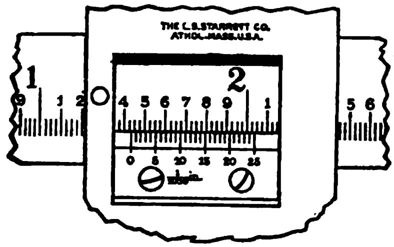


Fig. 10. The vernier scale as applied to a caliper or (scale rule reading in tenths of an inch).

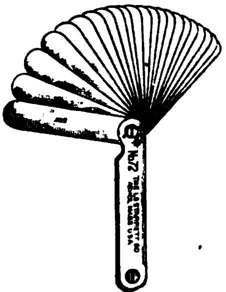


Fig. 4. Thickness gauge. This tool consists of flat steel leaves. In this particular one there are 22 leaves which vary in thickness from .004 (four thousandths) to .025 (twenty-five thousandths) of an inch. This tool is handy for measuring valve clearance, spark plug and interrupter point gaps, etc.

How to Read the Vernier.

The scale of the tool is graduated in fortieths, or .025, of an inch (40 times 25 thousandths equals 1000 thousandths or 1 inch), every fourth division, representing a tenth of an inch, being numbered. On the vernier plate is a space divided into twenty-five parts and numbered 0, 5, 10, 15, 20, 25. The twenty-five divisions on the vernier occupy the same space as twenty-four divisions on the scale which is marked off in tenths of an inch.

The difference between the width of one of the twenty-five spaces on the vernier and one of the twenty-four spaces on the scale is therefore 1/25 of 1/40 or 1/1000 of an inch.

If the vernier is set so that the 0 line on the vernier coincides with the 0 line on the scale (note the zero lines on the scale are marked with the large numbers 1 and 2) the next two lines will not coincide by 1/1000 of an inch; the next two lines will be two thousandths apart, and so on.

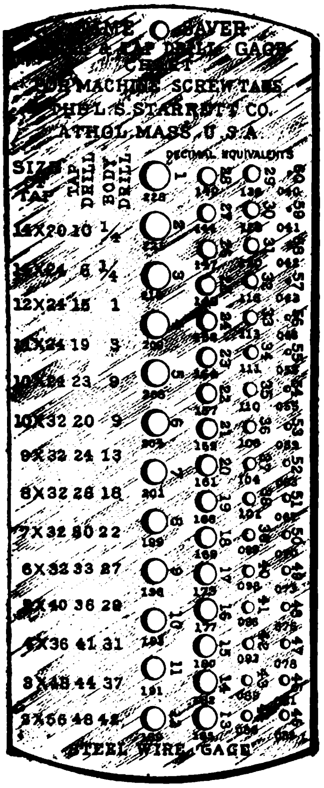
To read the tool, note how many inches, tenths and fortieths, the 0 mark on the vernier is from the 0 mark on the scale; then note the number of divisions on the vernier from 0 to a line which exactly coincides with a line on the scale.

In fig. 10, the vernier has been moved to the right one and four-tenths and one fortieth inches (1.425"), as shown on the scale, and the ninth line on the vernier coincides with a line on the scale. Nine thousandths of an inch are therefore to be added to the reading on the scale, and the total reading is one and four hundred and thirty-four thousandths inch (1.434"), which is the distance the jaws of the tool have been opened.

In making inside measurements the width of the jaws as given in the list is to be added to the apparent readings on the side having the vernier to allow for the space occupied by the measuring points. No such allowance is necessary when using the back line side, without vernier, as the two lines marked "in" and "out" indicate inside and outside measurements.

Drill Gauge (or gage)—How to Read.

By the use of this gauge one is enabled to select at once the right sized drill, to suit machine screw taps most commonly used, leaving just stock enough for the tap to cut as near a full thread as is practical for one tap without breaking it, thus saving much time and uncertainty of result attending the former crude ways of making a selection.



Explaining the illustration, the first row of figures, for an example, read thus, 14x20 10¼. The number 14 (in the first row of figures) means the number or size of tap; 20 the pitch or number of threads per inch; 10 the size of drill to use which will leave the right stock for proper thread; and ¼, size of drill to use to let this tap or screw through outside of the thread.

The figures—1, etc., up to 60—designate the number of drill (size agreeing with the holes). Other figures, 228, 221, etc., designate the size of hole in thousandths of an inch. See table No. 100, page 703, and table No. 106, page 706.

Example—Suppose you had a cap screw of a certain size and you found by referring to table No. 100, page 703, that it required a 10x32 tap. First find tap size 10x32 in column No. 1 (on the drill gauge.) Referring to column No. 2 (tap drill size), you will find that a drill is required of such size as will be a snug fit in the No. 20 hole. Referring to the No. 20 hole you will note that it has the decimal .161 under it. This is the diameter of the drill to use, in thousandths of an inch, and is the proper size for tapping, to insure a full thread.

Suppose, however, that in this particular job you were fastening a bracket or brace to the crank case or chassis, then it would be necessary to drill a large enough hole through the bracket so that the screw would pass through it (as there would be no threads required in this piece.) Referring to column No. 3 (body size of cap screw) you will find the proper size drill is the one that is a snug fit in the No. 9 hole and that the decimal size is .196 (196 thousandths.) By referring to table on page 541 of Decimal Equivalents the nearest size of these drills in 64ths can be found.

Note—In selecting a drill to drill a hole (whose diameter is expressed in thousandths) always select the nearest size to it, preferably a size or two larger. As an example take the decimals above—the first one was 161 thousandths, referring to the table on page 541, you will find that the nearest decimal to this is 171 thousandths this is equivalent to a 11/64ths drill. The second decimal was 196 thousandths and we find that the nearest size to this is 203 thousandths, equivalent to a 13/64ths drill. If you select a size smaller instead of larger, you run chances of breaking the tap when trying to cut the threads, especially in hard or very thick metals. While the larger drill doesn't give an absolutely full thread still it is in accordance with regular shop practice, (see foot note bottom of table No. 101 in chart 285-B).

CHART NO. 288-A—Measuring Instruments. How to Use Drill Gauge.

See page 511 for Thousandths Part of an Inch and pages 703 and 706, for Tap and Drill sizes.

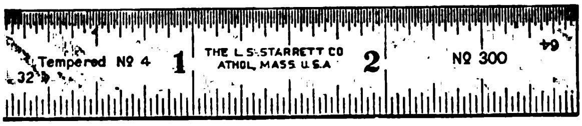


Fig. 18—A machinists steel rule or scale—These rules are of thin tempered steel and come in lengths from 2 to 24 inches long. The popular size is 6 inch, with graduations reading 64ths and 32nds of an inch on one side and 16ths and 8ths of an inch on the other side. They can also be obtained graduated in 10ths of an inch, also in millimeters as shown on page 540 and 541.

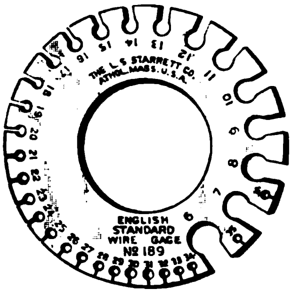

THE L. S. STARRETT CO.
ATHOL, MASS. U.S.A.
ENGLISH STANDARD WIRE GAGE
Nº 189

Fig. 20.

Fig. 20 — American standard wire gauge adopted by the brass manufacturers Jan. 1858. There are various gauges on the market, (some 7 or 8) and a gauge that meets the universal needs, is the kind to buy. This gauge will answer for all ordinary measurements. Decimal equivalents stamped on the reverse side.

Note— Measurements. are taken in the slots near the outer edges and not in the holes (as would appear.)

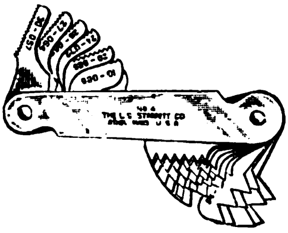

THE L. S. STARRETT CO
ATHOL, MASS. U.S.A.

Fig. 28.

Fig. 23—Screw pitch gauge for determining the number of threads to the inch on bolts, taps, etc. The shape of the blades make it applicable also for inserting in nuts and bolt holes. Sizes and decimal equivalents stamped on each blade. This particular tool is made in pocket knife form. (see fig. 2, chart 286), showing how used.

Chisels and Punches.

A center punch is used to punch center marks in metal parts to be drilled, giving the drill a center to start in and for reference marking, etc., see lower illustrations, page 707.

Chisels are made in many forms. The most popular is the **cold chisel** which is used for cutting metals. A **cape chisel** is next most popular and is used for cutting key ways and working in narrow grooves, channels, etc.

The diamond point chisel is shown in chart 286-B. It is used mostly for grooving in close places where a cape chisel could not be used.

Other popular chisels are round nose or gouge, used for cutting oil grooves in bearings and chipping out broken bolts or pipe threads from fittings. An assortment of small chisels and punches shown in fig. 24.

Machinist's Cold Chisel

Cape Chisel

Solid Punch

Cold Chisel

Center Punch

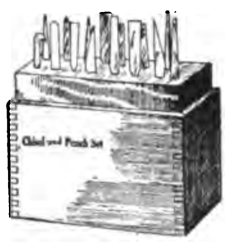


Fig. 24—The best way to buy chisels is in sets.

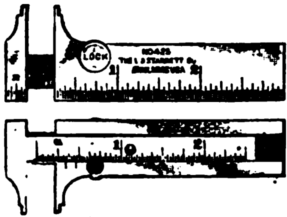


Fig. 19. A pocket slide rule, also called a caliper rule —usually made in 3 in. lengths. Graduated in 32nds on one side, and in 64ths on the other. Handy for measuring sheet or bar stock, wire, tubing etc.

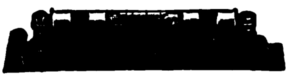


Fig. 21. Spirit level used for lining up pistons, connecting rods, etc., when used in conjunction with a steel square. (see chart 261) also used for finding grades as shown on page 589.

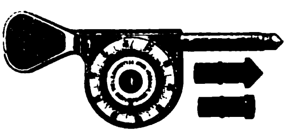


Fig. 22. Speed indicator, or revolution counter as it is sometimes called, is a necessity in high speed work. The dial can be set at the 0 mark and when timed with a watch for a minute or fraction thereof, will give the total revolution made by the crank shaft, line shaft, motor or generator.

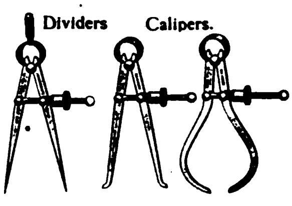


Fig. 5. Fig. 6. Fig. 7.

Fig. 5—Dividers are used to lay off circles and distances on metal. (see chart 286-B.)

Fig. 6—Inside calipers are used for measuring inside diameters, such as cylinders, bearings, etc.

Fig. 7—Outside calipers are used for measuring exterior diameters such as drill taps, etc. The caliper is adjustable and after measurement is taken the points of caliper are placed on a rule or scale to find the measurement in inches or fraction thereof.

Caliper dividers are made with and without springs—the spring is an advantage inasmuch as when once set they retain their setting. The non-spring type is shown on page 614.

Fig. 29—A hook rule for measuring diameter of flanges or circular pieces, through the hubs of pulleys, setting calipers or dividers etc.

Fig. 25—A scriber—used for scribing fine lines on planed surfaces of iron or steel, such as timing marks on fly wheels, etc. Points are of tempered tool steel.

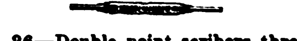


Fig. 26—Double point scribers threaded to screw into the holders and knurled for finger grip.

CHART NO. 284—Measuring Instruments, Chisels and Punches.

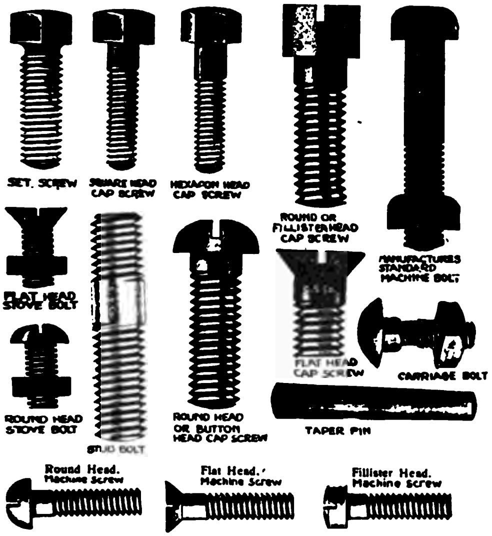


Fig. 1—Illustrations showing the different kinds of bolts and screws. The square head cap screw is seldom used. (see chart 247-DD.)

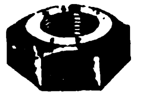


Fig. 2.

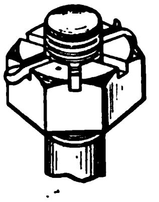


Fig. 8.

Fig. 2—A hexagon nut.

Fig. 3 — A "castellated" nut. The castellated nut is also hexagon but nut is slotted to take a cotter pin to prevent it coming loose.

Fig. 4—U. S. S. (United States Standard) cap screw and bolt thread.

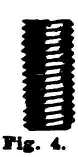


Fig. 4.

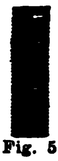


Fig. 5.

Fig. 5—S. A. E. Standard cap screw and bolt thread. These exaggerated illustrations are intended to show the only difference between a U. S. S. cap screw and an S. A. E. cap screw—which is in the thread. Note fig. 5—(S. A. E.) the thread is much finer, therefore more threads per inch.

By referring to table 101, chart 285-B, note a ¼ inch U. S. S. cap screw has 20 threads per inch. Whereas a S. A. E. cap screw (table 102, chart 285-B) has 28 threads per inch.

Bolts, Screws and Nuts.

Nuts are not usually used on capscrews as the cap screw is generally screwed right into the metal part. However, nuts can be put on to them and they be used in place of bolts.

Bolts always have nuts on them either square or hexagon and in most cases the nuts are larger than the head and consequently take a different size wrench—for instance a ⅝ machine bolt has a 1$\frac{1}{16}$ inch head and a ⅝ nut. Whereas an S. A. E. ⅝ cap screw has a $\frac{9}{16}$ inch head. (see chart 247-DD.)

The measurement for the diameter of a bolt or screw, is taken just below the head, where the metal is full diameter. If measured across the threaded part, they will be found to be of slightly less diameter due to the "flat." (see fig. 3, chart 285-A.)

U. S. S. & S. A. E. Bolt and Cap Screws.

The U. S. S. and S. A. E. cap screws are alike in all respects, with the exception of the pitch diameter and number of threads per inch. By referring to table No. 102, chart 285-B; you will notice the number of threads to the inch on the S. A. E. is more than on the U. S. S. (table 101).

On the auto we find bolts are used on the springs and various parts. In fact there is hardly a part of the entire mechanism that does not have its quota of bolts, capscrews, machine screws or carriage bolts (latter used for holding body to frame.) Stove bolts are used frequently for fender and drip pans.

Difference Between Bolts and Cap Screws.

The difference between a capscrew and a machine bolt, is mostly in the method of manufacture. In making a **capscrew** the usual method is to cut off a piece of the required length, from a piece of steel of hexagon shape and of the size required for the head, the piece is then turned down to the size required for the body and a thread cut on it (or it is milled.) In making a **machine bolt,** the stock is cut from a bar of round steel of the required diameter of the body and the head is then formed by a process called "upsetting." The machine bolt has a slightly larger diameter head than the cap screw but the threads are indentical in both.

The only difference between an S. A. E. bolt and an S. A. E. cap screw is in the amount of thread cut on it. The size and shape of head is the same and threads per inch is the same.

The difference between a U. S. S. bolt and a U. S. S. cap screw is also in the length of thread and the size of head. The thread on a cap screw is run down nearly to the head while on a bolt it is run down only about ⅛ of its length. The heads differ in that the bolt head is larger than the cap screw head and in the former is usually square instead of hexagon.

The difference between a machine screw and a machine bolt is mostly in the shape of the head. The screw has either a round or a flat head, but never a hexagon head and differs in the further respect in that the head is slotted for the reception of a screw driver.

A wrench that fits a U. S. S. cap screw **will fit** an S. A. E cap screw, because the heads are of the same size.

A wrench that fits a U. S. S. machine bolt **will not** fit an S. A. E. cap screw, because the U. S. S. bolt head is larger.

A wrench that fits a U. S. S. cap screw **will fit** an S. A. E. machine bolt, because the S. A. E. bolts have the same heads as cap screws.

A wrench suitable to fit any and all of the above is the adjustable S wrench, and open wrenches in sets. (see page 611.)

Studs, Taper Pins and Set Screws.

Studs are usually placed in the top of cylinders with detachable heads. The cylinder head is slipped over the studs and fastened down with hexagon nuts.

They are also used on top of crank case—see page 64 (E-117).

Taper pins require taper pin reamers—a reamer must always match the pin. (see page 796, for a taper pin reamer). Taper pins are used for—locking collars to shafts (where keys cannot be conveniently used), and various other purposes.

Set screws are usually cut full, so as to fit tight in the part to be held. They are either pointed or cupped at their lower ends and are either square headed or slotted. In using, set up tight and tap them directly on top with a light hammer, then tighten again. This will set the point or cup in the shaft. The threads are always U. S Standard.

When driving out bolts that are to be used again strike the hardest blow you can and use a heavy hammer. Light blows and the use of a small hammer will upset or rivet the bolt.

HART NO. 285—Different Kinds of Bolts and Screws—also see charts 247-D and 247-DD fo wrenches, 113-A for spark plug sizes and wrench sizes, 247-A for spark plug gaskets. Char 247-DD, gives the sizes of S. A. E. screws and bolts.

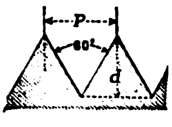


Fig. 1.

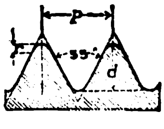


Fig. 2.

Fig. 1.—The sharp V thread (U. S. S.)

Fig. 2.—Whitworth's standard (oval). Note thread does not come to a point either top or bottom.

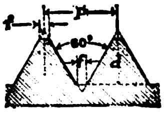


Fig. 3.

Fig. 3.—The U. S. S. (United States Standard) and S. A. E. thread. Note the flat at top of thread. This is also called the A. S. M. E. thread.

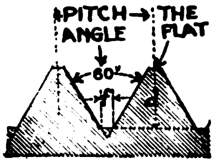


Fig. 5.

Fig. 5. — Explains the meaning of "pitch," "angle" and "flat." The pitch is the distance from one thread to another. The "angle" is the degree of slope and is usually 60° except Whitworth which is 55°. The "flat" is the top of thread coming to a flat instead of to a point.

Brigg's standard thread which is only for pipe, is oval like the Whitworth.

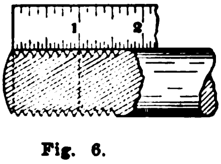


Fig. 6.

Fig 6. — The number of threads to an inch can be measured as here shown, or with a screw pitch gauge as per fig. 6, page 705.

The pitch is the number of threads per inch.

A screw pitch gauge (fig. 28, chart 284) is a quicker and more accurate method for finding the number of threads per inch.

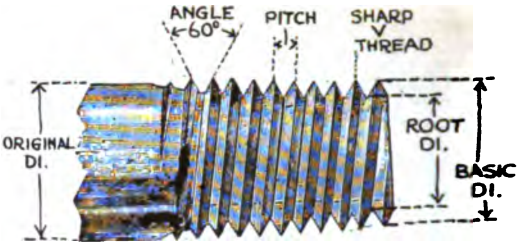


Fig. 8.—Explanation of the thread: Note the original size of stock on which thread was cut. Then note meaning of "angle," "pitch," and "V-thread." The "root diameter" is measured from base of threads and the "basic diameter" is measured from top of flats. (Used in this illustration merely to explain its meaning.)

Threads.

The two principal threads the repairman or mechanic should familiarize himself with, are the **bolt thread** and the **pipe thread.** A little study and use of the various sizes will enable him to know the particular kind and size by merely looking at it. A comparative difference in size between a bolt tap and a pipe tap is shown in figs. 14 and 15, page 704.

Note how much larger a ⅜ pipe tap is than a ⅜ bolt tap. This is due to the fact that a ⅜ pipe is measured on the inside and twice the thickness of the metal (of which the pipe is made) must be added to the ⅜" to get the diameter required. In the bolt tap the measurement is taken on the outside, consequently the tap is of practically the same diameter as the bolt.

U. S. S. and S. A. E. Used Most.

***The threads most commonly used** in this country are the **United States Standard and the S. A. E. formerly A. L. A. M.** This latter is the standard adopted by the (Society of Automobile Engineers) for automobile work.

The diameter and angle of the S. A. E. thread is the same as the U. S. Standard, the only difference being in that the **S. A. E. thread is of finer pitch** (see fig. 5, chart 285), or more threads to the inch. Take for instance a U. S. standard ¼" screw, it has 20 threads per inch, while a ¼" S. A. E. screw has 28 threads per inch (see tables 101 and 102, chart 285B). This finer thread has been found by experience and tests to have several advantages over the coarse U. S. S. thread in auto construction, one of which is the incessant vibration to which a fast moving automobile is subjected to. A nut with fine threads takes more revolutions or turns to remove it than one with coarse threads and the chances are that were the threads coarse the nut would be far more apt to be lost, whereas the fine thread nut with the same number of turns would be only loose. There are various other reasons, of as much or more importance which led the manufacturers to adopt this finer thread.

The fine thread is nearly always used where hardened material is employed (as case hardened) and the coarser thread where soft material—as aluminum, brass, bronze, etc.

Other thread standards used somewhat in this country (although they are made principally for foreign business) are the Whitworth Standard (fig. 2) and the Metric or French Standard (not illustrated).

Pipe Threads.

The Briggs Standard (table 103) is for pipe work only and has no connection with screw work.

Pitch of thread; by this is meant the number of threads per inch, or the distance from the top of one thread to the top of the next. This pitch is always the same for the same size bolt, nut, tap or die of the same standard.

To Find the Pitch or Threads Per Inch.

To find the pitch of a screw when a thread gauge is not convenient, place a scale on the screw (fig. 6) so that the end of the scale is opposite the top point of any thread; count the number of spaces under the scale between the threads, for a distance of one inch, viz.: There are eight spaces underneath the scale in one inch, therefore, the screw is ⅛" pitch or eight threads per inch. **Another method** is to place the scale as shown in fig. 6, and count the top of the threads for a distance of one inch, omitting one thread. The reason for omitting one thread may be seen by following the two dotted lines drawn from the top point of the first and 9th threads; count the number of complete threads between the dotted lines at the bottom of the screw, and you will find it to be eight.

Pitch angle; by this is meant the angle or degree of slope that the sides of the individual threads have and is always 60° in the various standards with the exception of the Whitworth which has 55°. This angle clearly shown in fig. 2. **Flats:** see fig. 3—note U. S. S. and S. A. E. use this thread—but while the angle and flat are the same, the S. A. E. is of finer pitch or more threads per inch.

In tables 101 and 102, chart 285-B, a tabulation of sizes and threads per inch, from ¼" to 1" for U. S. and the S. A. E. standards, **also the drill size to use for drilling a hole preparatory to tapping** or cutting the threads is given.

Root Diameter Determines Drill Size.

Root diameter; means the diameter of the bolt measured from the bottom of one thread to the bottom of the thread diametrically across from it and is the measurement that must be taken into account when figuring the working strength of the bolt and **is the diameter that gives you the drill size.**

In practice the drill size is a little larger, so that after a thread is cut it will be found that it is not really a full thread, but is full enough for all practical purposes if drill is not unnecessarily large.

*The sharp V-thread, fig. 1, with its razor like edge, is a thread the manufacturers do not favor. The flat thread, fig. 3, is the one favored.

†The length of a thread on a cap screw is more than on a bolt.

'HART NO. 285-A—Threads; Different Kinds. How to Find the Number of Threads per Inch, etc.

TABLE NO. 100.

Size of tap and drill to use for U. S. S. (United States Standard) or A. S. M. E. (American Society of Mechanical Engineers) —screw thread.

First and sixth column gives the size tap designated in numbers; **Second and seventh column**, the outside diameter of tap; **Third and eighth column** the number of threads per inch; **Fourth and ninth column** the size drill expressed in decimal parts of an inch; **Fifth and tenth column** the number, or size of drill which is necessary to drill the hole for the tap.

Example: suppose, on the tap the numbers 14-20 appeared. This would mean that the tap number was 14 and 20 is the number of threads per inch. Therefore by referring to the sixth and tenth column, the size tap to use would be No. 14 and the size drill to use for this tap would be No. 10 drill which is .1982 inch diameter. see page 706 explaining drill numbers and page 705 explaining tap numbers.

Size of Tap	Out-side Diam	Threads per Inch	Nearest Commercial Size Drill producing 75% depth of thread		Size of Tap	Out-side Diam	Threads per Inch	Nearest Commercial Size Drill producing 75% depth of thread	
			Inch Decimals	Commercial Designation				Inch Decimals	Commercial Designation
0	.060	80	0478	3/64	9	177	24	1364	29
1	.073	72	0595	53	+10	.190	32	.1610	21
1	.073	64	.0577	54	10	190	30	1575	21
2	.086	64	0707	50	+10	190	24	.1496	25
+2	.086	56	0686	53	12	216	28	.1812	14
3	.099	56	.0816	45	+12	.216	24	.1754	16
+3	.099	48	.0786	47	14	.242	24	2014	7
4	.112	48	.0916	42	+14	.242	20	1932	10
4	.112	40	.0876	43	16	268	22	.2237	I
+4	122	36	0849	44	16	.268	20	2192	7/32"
5	.125	44	.1028	37	18	.294	20	.2452	D
5	125	40	1006	38	18	.294	18	.2398	C
5	125	36	.0979	40	20	.320	20	.2712	I
6	.138	40	.1136	33	+20	.320	18	.2658	H
6	.138	36	1109	34	22	.346	18	.2918	M
+6	.138	32	.1075	36	22	.346	16	.2851	K
7	151	36	.1239	⅛"	24	.372	18	.3178	O
7	.151	32	.1205	31	+24	.372	16	.3111	5/16"
7	151	30	.1185	31	26	.398	16	.3331	R
8	.164	36	.1369	28	26	.398	14	.3284	21/64"
+8	.164	32	.1335	29	28	.424	16	.3631	U
8	164	30	.1315	30	28	.424	14	.3544	T
9	177	32	.1465	26	30	.450	16	.3891	25/64"
9	.177	30	.1445	27	30	.450	14	.3804	V

NOTE: A common nut, drilled out so that it only contains 50% of a full depth thread will break the bolt before it will strip.

A 75% depth of thread yields an ample margin of safety (2 to 1) and is economical in tapping.

A full depth of thread in a common nut is only about 5% stronger than a 75% depth of thread; yet it requires three times the power to tap.

Note—A ¼ inch S. A. E. tap is larger in dia. than a U. S. S. ¼ inch tap, due to the difference in the root diameter of the bolt or screw. see page 702 explaining root and basic pitch.

How drills are designated; refer to table No. 106, page 706 which explains how certain sizes of drills are **lettered** instead of numbered etc.

TABLE NO. 103.

Tap and drill size for pipe threads. This table gives the size drill to use for a certain size pipe tap. The Briggs standard is the one used in this country. Note the threads on a ¼ inch pipe tap are 18 to the inch, whereas on the S. A. E. (table 102) there are 28 and on the U. S. S. (table 101) there are 20 threads per inch.

The diameter of a pipe tap is larger than a stated size of any other tap—see page 704 explaining why.

Size Tap Inches	BRIGGS STANDARD	
	Thread	Drill
⅛	27	21/64
¼	18	27/64
⅜	18	9/16
½	14	11/16
⅝		
¾	14	29/32
⅞		
1	11½	1⅛

Table No. 103.

TABLE NO. 101.

Tap and drill sizes for U. S. S. threads—This tables gives the diameter of tap and threads per inch and size drill to use **(expressed in common fractions) for the tap.** The diameter of the tap expresses the screw size. For instance a ¼ inch tap is for a ¼ inch screw with 20 threads—therefore the size drill to use would be 3/16 inch, etc.

Example: To find what size and number tap to use for a ¼ inch U. S. S. bolt with 20 threads to the inch. First find the decimal equivalent of ¼ inch (page 541.) ¼ inch is equal to 2/8 inch, so by looking in column under heading of 8ths, you will find that ¼ or 2/8 is equal to 250 thousandths or point 250. Referring back to (table 100) find the nearest decimal, this will be found in column No. 7 and can be either .242 or .268 so you could use either a No. 14 or a No. 16 tap .

To find what would be the number of the drill for a ¼ inch U. S. S. tap, 20 threads to the inch. Proceed as in the previous instance, first find the decimal equivalent of ¼ inch. This you have found to be 250 thousandths. The nearest decimal to this is in column No. 7 and can be as before, either .242 or .268 and the proper drill corresponding thereto is found in column No. 10 and can be either a No. 10 drill or a 7/32 inch drill. You will notice by referring to (table 101)—that a 3/16 inch drill will also answer.†

Diam. Tap in Ins.	Thds. per inch	Size of Drill Ins.	Diam. Tap in Ins.	Thds. per inch	Size of Drill Ins.	Diam. Tap in Ins.	Thds. per Inch	Size of Drill Ins.
¼	20	3/16 in.	9/16	12	29/64	1¼	7	1 5/64
5/16	18	¼ in.	⅝	11	33/64	1⅜	6	1 11/64
⅜	16	5/16 in.	13/16	11	37/64	1½	6	1 19/64
7/16	14	⅜ in.	¾	10	⅝			
½	13	11/32 in.	11/16	10	11/16			
½	12	13/32 in.	⅞	9	47/64			
			15/16	9	51/64			
			1	8	27/32			
			1⅛	7	61/64			

Table No. 101.

Note — The only difference it would make in using one or the other of the various drills, would be in the fullness of the thread. The larger the drill the less depth of thread. You can readily see that by using a drill too large you would cut away the metal that should go to make the thread and on the other hand, if you use a drill too small, you would not be able to enter the tap. (See foot note bottom of table 100).

TABLE NO. 102.

Tap and drill size for S. A. E. This table gives practically the same information as table No. 101 —but for S. A. E. cap screws. The first column gives the size tap to use, second column, the number of threads to the inch (pitch); the third column, size drill to use.

To find what number of tap would be required or the number of drill, would be the same procedure as in table 101. The diameter of drill and tap would be the same as for the U. S. S. but the number of threads per inch would be greater, as would also be the root diameter. A comparison of the two drills for the 5/16 taps for instance will make this clear.

Diam. in.	Pitch	Tap Drill
¼	28	No. 4
5/16	24	17/64 in.
⅜	24	21/64
7/16	20	⅜
½	20	7/16 in.
9/16	18	½
⅝	18	9/16
11/16	16	39/64
¾	16	43/64
⅞	14,18	51/64, 13/16
1	14	59/64

Table No. 102.

*No. 4 drill is 7/32 inch. *The ⅞—18 threads is for S. A. E. spark plug.

†In practice it is best to use a larger size drill. if the exact size cannot be had.

HART NO. 285-B—Tables Giving the Tap and Drill Size to Use for U. S. S., S. A. E. and Pipe Threads. See chart 247-DD for S. A. E. and U. S. Standard screw and bolt tables and S. A. E. spark plug sizes.

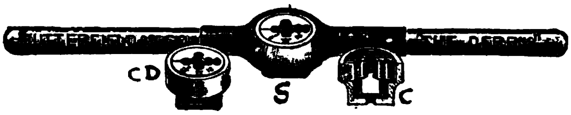


Fig. 8—Methods of cutting male threads are with a die or on a lathe. When a die is used, it is placed in a collet (C) and the collet and die (CD) are then placed in a stock (S). This is worked over the part to be threaded. The illustration shows a die and stock for cutting threads on machine screws.

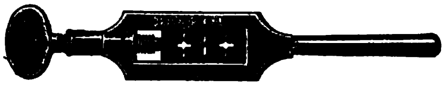


Fig. 8-A—A screw plate or gunsmith's die. It cuts threads in the same manner as the one shown in fig. 8, but there is no collet. Bicycle dies are often made in this form.

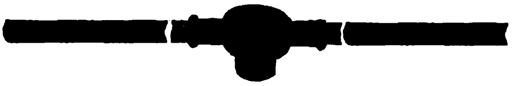
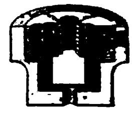


Fig. 8-B—A stock and die for cutting threads on pipe. The pipe is held stationary and tool revolved.

Die without Collet



SECTIONAL VIEW COLLET AND DIE

Dies.

The subject of dies is really a part of the tap subject inasmuch as where the one is used, the other must be used also. The tap cuts a thread on the inside and the die cuts the companion thread on the outside. Thus you would "tap a hole" or nut and "run a die over" a bolt or pipe.

With dies as with taps, they are divided into two classes, **pipe dies and bolt dies.**

The better grade of dies are adjustable as to size, that is, you can make them cut a little larger or a little smaller than "standard." This will be found to be of special value in repair work.

The solid die is non-adjustable and when worn will not cut deep enough, as a consequence the nut or fitting is nearly ruined by forcing it on. It sometimes happens that a cutting lip is broken off; this necessitates the purchase of an entire new die, whereas in the adjustable die one can renew—just the broken lip—at slight expense.

How marked: Dies are marked as to size, threads per inch and whether right or left hand thread, designated by the letter R or L. In a great many instances it is both necessary and convenient to cut a left hand thread and it is advisable to have a few of the most used sizes on hand. (A brake rod for instance, where it screws into the turnbuckle has a left hand thread).

Dies and their corresponding taps are so made relative to the diameters at the top and bottom of thread, that when the nut is screwed onto the bolt, the extreme tops do not touch one another, in other words there is a small space allowed, called the **clearance** (about .002 inch.) The real bearing surfaces are the angular sides of the thread. This clearance space is accountable for the rust that is found in the threads of old bolts and nuts and it is in this space that the kerosene soaks in, when applied to loosen up a rusty nut.

See chart 247-E for illustration of a set of dies of various sizes and also the stocks in which they are used—also tap wrenches.

The stock—is the holder for the die while cutting and usually has removable handles.

Screw plate set is a term used to express the entire outfit, as shown in chart 247-E. Although we have shown fig. 8 as a die and fig. 8-A as a screw plate—the term is used as above stated.

Screw Taps.

Taps may be divided into two distinct groups; bolt and pipe taps.

Machinists hand taps are used for cutting internal threads in metal and are usually bought in sets of 3, viz: taper, following, and bottoming.

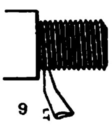
Pipe taps are used for cutting threads in pipe fittings and cutting threads for the insertion of pipes, pet cocks, drain plugs, etc. (see fig. 15, also table 103, chart 285-B.)

The taper tap: (fig. 13, also No. 1, chart 286) so called owing to its sides being tapered is the one first used after hole is drilled. This is in reality a roughing tool and does not give a full thread unless run all the way through. It is used for open work such as the truing up of the threads in a nut and also for tapping various parts of the chassis.

The following tap: (fig. 13, also No. 2, chart 286) is next used and in the majority of cases is all that will be required to finish the tapping process. Where tapping is done in solid metal, this is the one generally used. If threads are desired, clear to the bottom of solid work, then the bottoming tap is used.

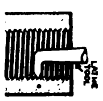
The bottoming tap: (fig. 13, also No. 3, chart 286.) In many instances, the thickness of the metal is such that a tap cannot be run in far enough to cut a complete thread all the way to the bottom of the hole, it is therefore necessary to use the bottoming tap. There is no taper to this tool, consequently it cuts full size from start to finish and thread must be started with one of the other taps first.

Flutes: This term applies to the grooves cut in the sides of taps for the reception of iron cuttings or chips and any foreign matter that might be present whilst cutting. It is the almost universal practice to make taps with 4 flutes, as shown in end view, fig. 2, chart 286, this makes it convenient to caliper the diameter—which otherwise could not be so easily done if there were 5 or any other odd number of flutes.



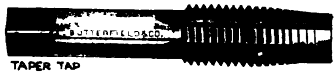
9

Fig. 9--Threads may also be cut on a lathe, note the lathe tool cutting an outside or male thread.

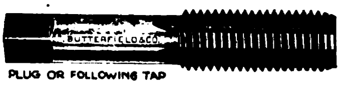


12

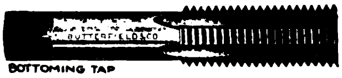
Fig. 12—Note lathe tool cutting an inside or female thread. The tool is held stationary. Just the reverse of hand cutting.



TAPER TAP



PLUG OR FOLLOWING TAP



BOTTOMING TAP

Fig. 13—The machinists hand taps are explained in the text.

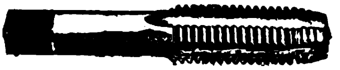


Fig. 14 and 15 are illustrations intended to show the comparative difference in size between a ⅜ machinists hand tap and a ⅜ pipe tap, as explained in text.

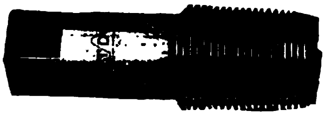


Fig. 15—A pipe tap.

CHART NO. 285-C—Cutting Threads. Stocks and Dies. Taps. Comparison of Bolt and Pipe Taps.

—continued from chart 285-C.

U. S. S. & S. A. E. Taps.

Sizes of tap: After proper size hole is drilled, it will be then in order to get the proper size and standard of tap necessary to cut the thread. Suppose you wished to tap a hole to fit a 3/8 S. A. E. screw. If you drilled the hole of such size as called for in table 102, chart 285-B, you would have used a 21/64 inch drill, therefore you would call for a 3/8 inch S. A. E. tap. If the bolt or stud was the U. S. Standard 3/8 inch size, use a 5/16 inch drill as per table 101. (Note that the S. A. E. tap is 1/64 inch larger than the U. S. S.) chart 285-B and use a 3/8 inch Standard tap. If, on the other hand you are working on a 3/8 inch pipe job instead of a bolt job, you would have used a 9/16 inch drill (see table 108, chart 285-B) therefore use a 3/8 inch pipe tap. Notice that the drill used for a 3/8 inch pipe tap is nearly twice as large as that used for a Standard bolt of the same size. see figs. 14 and 15, page 704, for relative size.

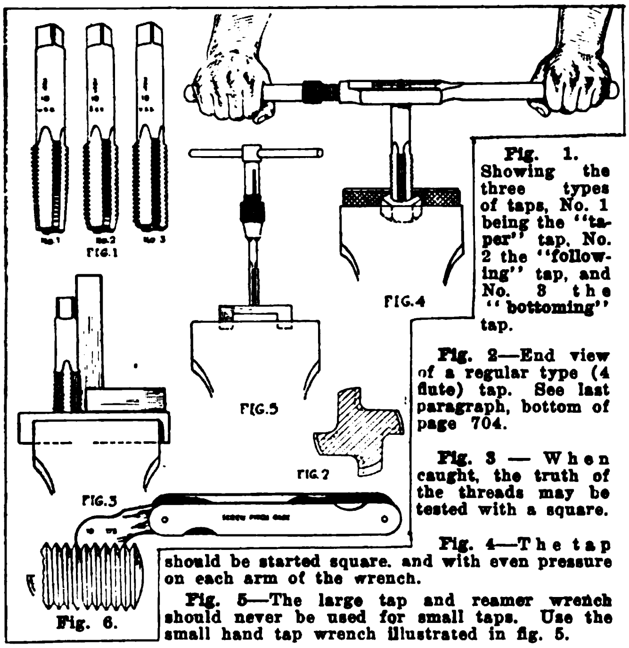


Fig. 1. Showing the three types of taps, No. 1 being the "taper" tap, No. 2 the "following" tap, and No. 3 the "bottoming" tap.

Fig. 2—End view of a regular type (4 flute) tap. See last paragraph, bottom of page 704.

Fig. 3 — When caught, the truth of the threads may be tested with a square.

Fig. 4—The tap should be started square, and with even pressure on each arm of the wrench.

Fig. 5—The large tap and reamer wrench should never be used for small taps. Use the small hand tap wrench illustrated in fig. 5.

How To Use Taps.

Before using a tap, the hole must be drilled to the proper size, as given in chart 285B. Never use a monkey wrench or an S wrench unless in a tight corner—as there is a liability of breaking the tap.

Get the work perfectly level and rigid before starting the tapping—and start tap true.

When tap is caught, sight or use a square (fig. 3) to see if it is true; and if not, turn the tap backward, and then forward, pressing in the direction required to straighten on the forward stroke only.

Start the tapping with a No. 1 tap, or "taper" tap; followed by the No. 2 or "following" tap, and if threads are desired a little large, or particularly clean, and to the bottom of a hole, then use the "bottoming," or No. 3 tap.

Lard oil should always be used on taps, or dies, never a mineral oil.

Brass or cast iron requires little oil; steel, a continued application, and the tap should not be forced during the cutting. If the tap sticks, backing off, and starting over will usually permit the tapping to be done with little exertion.

Several methods are commonly employed to make a tap cut oversize. One is to pack the groove with cotton waste; another to place a thin strip of copper or brass over one cutting lip, and another to place the tap in boiling water, and cut the thread while the tap is still hot. Of the three, the first is perhaps the best method.

Taps How Marked.

You will find on all taps, at least 2 marks; they refer to the diameter and the threads per inch. Thus, a tap marked (1/4-20) or (1/4-28) will denote that the tap is for 1/4 inch size nut or hole and has 20 or 28 threads per inch. The (1/4-20) is a U. S. S. tap and the (1/4-28) is an S. A. E. tap.

A great many taps are marked with a number instead of a fraction thus (14-20) this means that the number of the tap is 14 and the threads are 20 to the inch. In (table 100, chart 285-B) is shown a complete list of tap numbers from 0 to 80. Those marked with a + mark are the sizes most used for ordinary work. The table also gives the proper size of drill to use with the various taps. The dimensions are given in thousandths of an inch. By referring to table on page 541 of "Decimal Equivalents" you can get the proper size in fractions of an inch.

Tap Sizes.

Sizes of numbered taps: Taps from No. 1 to 80 run from 1/16 to 7/16 in. outside diameter, varying approximately, by 32nds.

Numbers above 80—are marked according to the size and thread; for instance a 1/2 inch tap (U. S. S.) would be marked (1/2-13), meaning 1/2 inch size and 13 threads to the inch. When taps are marked in this manner they run from 1/2 inch to 1 inch, varying in 1/16 of an inch sizes or fractional part of an inch.

Size taps most used—a set for small work; would be from No. 1 to 14 (chart 285-B, table 100), which runs from 1/16 to 1/4 inch with variations by sixteenths, then from 5/8 to 1 inch, varying in eights of an inch. Taps are seldom used over 1 inch for general auto work.

*Special Taps for Spark Plugs.

For regular 1/2 inch size (fig. 4, page 288), with 14 threads per inch, use the regular standard 1/2 **pipe tap** and a drill 11/16 inch (see table 108, chart 285-B.)

For S. A. E. 7/8 inch size with 18 threads per inch, use the S. A. E. 7/8 inch "special spark plug tap." Note by referring to table 102, chart 285-B, that the standard 7/8 S. A. E. screw tap has 14 threads—and the S. A. E. spark plug has 18 threads. It is for this reason that a special tap is required. A 13/16 inch drill is the proper size to use.

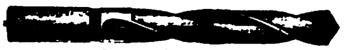
The metric 18 m. m. size uses the metric 18 m. m. spark plug tap. (French Standard).

See page 612 for S. A. E. spark plug dimensions, and 239, 607 and 717 for spark plug gaskets.

CHART NO. 286—How to use Taps for Tapping Threads. Screw Pitch Gage.
(Motor World.)

A STRAIGHT SHANK FLUTE DRILL

Taper Shank Drill



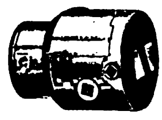
Straight Shank Drill

Blacksmiths' Drill

Bit Stock Drill

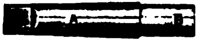
Taper Shank Ream.

Drill Chuck.



Taper Arbor

Taper Shank



Drills.

Twist drills are the kind always used for boring in met They are generally made with two flutes or spiral grooves, the reception of the cuttings or chips of the metal being drilled.

Flute drills are those having flutes or grooves arranged lon tudially along their length. They are mostly used for soft met and are the kind which usually come with hand drills in sma sizes.

Shanks—the part that goes into the chuck is called the shank The shanks most generally used for a power drill press are eith straight or taper.

Straight shank drills are used in lathes or in drill chuc For instance, where a straight shank drill is desired to be u in a power drill press which takes a taper shank only—the **taper arbor** (B) can be fitted in end of ****drill chuck** (C) and t tapered end of taper arbor (A) can be inserted in the drill pre This method is usually employed where the drills are ⅛ in or less.

Taper shank drills fit into the drill press without the use o drill chucks.

Taper Shanks.

Taper shanks on drills vary—therefore, drill presses are usually fitted with four sizes of taper shanks as follows:

For drills 1/16 to 9/16" with No. 1 taper shank.
For drills 37/64 to 29/32" with No. 2 taper shank.
For drills 59/64 to 1¼" with No. 3 taper shank.
For drills 1 17/64 to 2" with No. 4 taper shank.

*How Drills are Designated in Sizes.

Note table 106. You will observe that in the sizes from 1½" to No. 80—(0.013 or 13/1000ths of an inch) the drills are numbered and lettered. The No. 80 is the smallest size. In other words, the larger the number, the smaller the drill. (see also Drill Gauge, on page 699.)

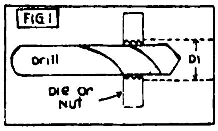
Drills from No. 80 to No. 1 (1/64th to 7/32nds) **do not bear size numbers or letters marked on them**, but are measured on drill gauges per chart 288-A.

Drills from No. A to Z (¼ to 13/32nds) have their size designated by letters stamped on their **shank**.

Drills from Z to 1½ inch, the actual size is stamped on them, as 27/64 to 1½.

Comparison of table 106 and table 100. The exact size of a No. 80 drill, for instance **as given in table** 106, is 127 thousandths of an inch and in table 100, 4th column it is **given** as 131 **thousandths. This** difference is only slight and does not **affect** the strength of thread. This difference is due to **using tables** of actual drill size (table 100), and table of drill rods (table 106).

Fig. 1—One method for finding the size drill to use for tapping, is to select one that will be a sliding fit in the die which goes with the tap. If the drill is too large to



go into the die (a nut will do just as well) the threads will not be full and if it is smaller than the die or nut, the tap will turn so hard it will probably break.

Reamers.

Fig. 9: Are used a great deal in auto work as they enable one to enlarge a hole to any desired size (in thin material) without having to resort to any particular size drill. Simply drill a small hole and ream it out to size. Tapered reamers can be had, that come to a sharp point. The one shown in fig. 9 is the blunt type. Note—don't confuse **a taper reamer** with **a taper shank reamer.** See chart 287, "Reaming a Hole."

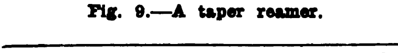


Fig. 9.—A taper reamer.

†TABLE NO. 106.

Drills from No. 80 to 1½ inch size. D. E.—means decimal equival For instance, a number 1 drill is .227 (two hundred and twenty-seve thousandths of an inch diameter).

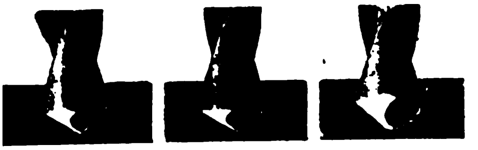
Size drill	D. E	Size drill	D. E.	Size drill	D. E.	Size drill	D. E.	Size drill	D. E.
1½	1.500	3/8	0.375	1	0.227	27	0.143	52	0.063
1¼	1.250	U	0.368	2	0.219	9/64	0.1406	1/16	0.0625
1	1.000	23-24	0.3593	7/32	0.2187	28	0.139	53	0.058
31/32	0.969	T	0.358	3	0.212	29	0.134	54	0.055
15/16	0.937	S	0.348	4	0.207	30	0.127	55	0.050
29/32	0.906	11/32	0.3437	5	0.204	1/8	0.125	3/64	0.0468
7/8	0.875	R	0.339	13/64	0.2031	31	0.120	56	0.045
27/32	0.844	Q	0.332	6	0.201	32	0.115	57	0.042
13/16	0.812	21/64	0.3281	7	0.199	33	0.112	58	0.041
25/32	0.781	P	0.323	8	0.197	34	0:110	59	0.040
3/4	0.750	O	0.316	9	0.194	7/64	0.1093	60	0.039
23/32	0.719	5/16	0.3125	10	0.191	35	0.108	61	0.038
11/16	0.687	N	0.302	11	0.188	36	0.106	62	0.037
21/32	0.656	19/64	0.2968	3/16	0.1875	37	0.103	63	0.036
5/8	0.625	M	0.2950	12	0.185	38	0.101	64	0.035
19/32	0.594	L	0.290	13	0.182	39	0.099	65	0.033
9/16	0.562	9/32	0.2812	14	0.180	40	0.097	66	0.032
17/32	0.531	K	0.281	15	0.178	41	0.095	1/32	0.0312
1/2	0.500.	J	0.277	16	0.175	3/32	0.0937	67	0.031
31/64	0:4843	I	0.272	17	0.172	42	0.092	68	0.030
15/32	0.4687	H	0.266	11/64	0.1718	43	0.088	69	0.029
29/64	0.4531	17/64	0.2656	18	0.168	44	0.085	70	0.027
7/16	0.4375	G	0.261	19	0.164	45	0.081	71	0.026
27/64	0.4218	F	0.257	20	0.161	46	0.079	72	0.024
Z	0.413	E	0.250	21	0.157	5/64	0.0781	73	0.023
13/32	0.4062	1/4	0.250	5/32	0.1562	47	0.077	74	0.022
Y	0.404	D	0.246	22	0.155	48	0.075	75	0.020
X	0.397	C	0.242	23	0.153	49	0.072	76	0.018
25/64	0.3906	B	0.238	24	0.151	50	0.069	77	0.016
W	0.386	15/64	0.2343	25	0.148	51	0.066	1/64	0.0156
V	0.377	A	0.234	26	0.146			78	0.015
								79	0.014
								80	0.013

Shields Mechanics Guide Hand Book.

CHART NO. 286-A—Drills. Straight and Taper Shanks. How Marked for Sizes. Reamers.

*See chart 285-B for size drills to use for U. S. and S. A. E. taps.

See chart 247-G for a drill and lathe chuck. †This table is size of **drill rods, see above, "comparison of table 106 and 100."



RESULTS OF IMPROPERLY GROUND DRILLS
Left—Fig. 5—Unequal lip angles. Middle—Fig. 6—Unequal lip lengths. Right—Fig. 7—Both lip angles and lengths unequal

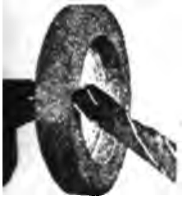


Fig. 8—Proper method of starting to grind a drill

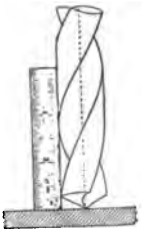


Fig. 9—Method of measuring cutting lip length

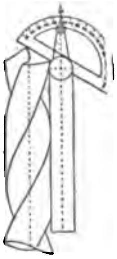


Fig. 10—Measuring lip angles

See page 541, how to read angles in degrees.

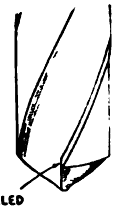


Fig. 11—Method of beveling cutting lip to cut thin or hard material

How to Sharpen Drills.

Few mechanics know how to sharpen a drill or how to tell when it is properly sharpened. Four factors are essential. They are:

1–Both cutting lips should have the same angle to the axis; otherwise the cutting will all be done by one lip and the drill will drill oversize. (see fig. 5.)

2–Both cutting lips should be exactly the same length. Otherwise it will throw the point of the drill off-center, causing the drill to cut oversize. (see fig. 6.)

3–Proper clearance back of the cutting edge. Insufficient clearance causes the drill to drag, cut hard and get dull quickly.

4–The angle of the lips should be about 60° each.

*To Sharpen.

5–Hold the drill lightly against the wheel, as shown in fig. 8, with the cutting lip on the wheel. Wheels for drill grinding should be fairly soft and open so they will not clog or burn. The drill should be pressed lightly against the wheel and carefully watched to see that it is not burned and the temper drawn. Watch the surface from which the grinding wheel leaves, as the heat is concentrated there. (see pages 696 and 711 for tempering drills and small tools.)

6–Twist the drill and at the same time throw the right hand down in order to grind the proper clearance.

7–Check the length of the cutting lip, as shown in fig. 9.

8–Check the angles of the cutting lips, as shown in fig. 10. The best cutting angle is 60 degees.

Drilling.

9–Brass or thin sheet metal may be more readily drilled if the cutting lips are beveled, as shown in fig. 11. This prevents the drill from digging in and catching.

10–Always clamp or hold the work being drilled to prevent drill catching and breaking, and place a block of wood under the work.

11–In starting to drill use moderate speed, gradually increasing until the best cutting speed is obtained.

12–When drilling small holes, speed the drill up and go carefully when the drill is breaking through the work. This is the point where the drill usually catches and breaks.

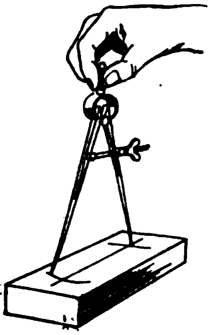
13–When drilling large holes, say ⅝ in. to ¾ in. dia., it is better to drill a small hole first.

14–It is advisable to always make a center punch mark in metal to be drilled.

15—Case hardened steel must first be softened until an even red heat is reached, and re-hardened again.

16–The following are the cutting compounds for the various metals: **Hard steel**—turpentine, kerosene; **soft steel**—lard oil, machine oil; **brass**—soda water, if anything; **aluminum**—kerosene; **cast iron**—none. An air blast is a very good cooling medium for cast-iron drilling.

17–If the drill chips out at the cutting edge there is too much feed, or the drill has been ground with too much clearance. A split up the web is caused by the same improper grinding.

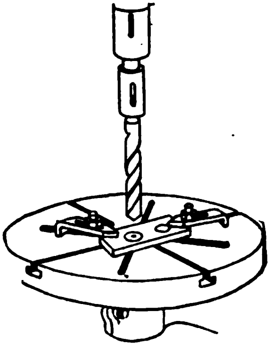


Accurately mark off the center distances with a pair of steel dividers, after first lightly prickpunching one center

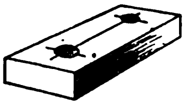
Laying Out Work For Drilling.

The easiest way to lay off work for drilling, etc., on iron or steel is to cover it with a coating of chalk, which permits the lines scribed on the surface with a steel pointed instrument so as to be readily seen.

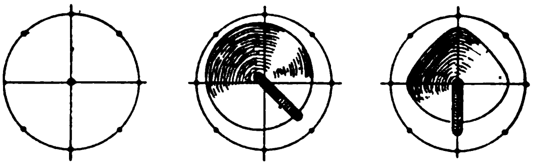
All lines showing the size, location of holes, etc., are scribed out on the metal, previously chalked over, as aforementioned, or if on wood, simply by a hard pencil, and all centers of holes to be drilled should then be center punched by a hard steel punch.



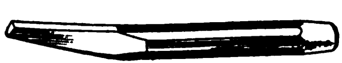
—The piece must be clamped to the drill table by steel clamps. Otherwise the drill will wander, destroying the accuracy of the hole



The finished piece, with the center lines scribed



Left—The piece prepared and ready for drilling. The prick punch marks should be made carefully and lightly. —Middle—The groove should be made the depth that it is desired to draw the drill, and on the side that the drill is to be drawn. —Right—A triangular hole may be corrected in the manner illustrated



A diamond point should be used in "drawing" the drill.

Fig. 8. When drilling a piece of thick metal and drill has a tendency to bore crooked or off the center, it can be re-centered again by cutting a groove with a diamond point chisel on the side towards which you wish to draw the drill, as here shown.

CHART NO. 286-B—Drills and Drilling. Correct and Incorrect Cutting Lip for Drilling. Us of Spring Dividers for Laying Out Work. Re-Centering a Drill. (Motor World.)

See page 703 for drill sizes to use for U. S., S. A. E. Standard thread. *See page 616 for drill grinder.

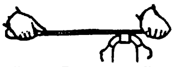


Fig 16—How to hold a file

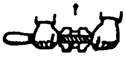


Fig 17—Draw filing

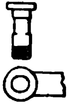


Fig 22—Worn steering pin and rod

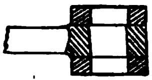


Fig. 23—Drill gone wrong showing hole uneven.

How To File—Draw Filing.

The art of perfect filing, is a very difficult one; few men can file truly flat. The reason is not very far to seek.

Fig. 16 represents the position of the file at the beginning of the stroke. If the pressure of the hand be equal through the stroke, it will be greatest on the corner nearest the workman at the commencement, and on the other corner at the end of the stroke—due to the leverage—and will tend to form a curved surface by imparting a slight rocking action to the file.

Therefore, the pressure on the file must be greatest on the left hand at the beginning of the stroke, and as the file crosses the work, must be gradually diminished on the left hand and at the same time increased on the right hand.

Notwithstanding this, it is impossible to file truly flat. If the work be examined with a straight-edge it will be found higher in the middle.

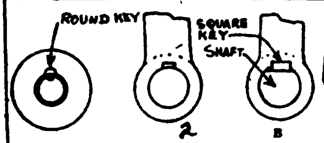
To reduce this high part recourse must be had to draw filing (fig. 17), holding the file by both ends and working it backward and forward across the middle of the work. This will considerably reduce the high part. (see chart 247-F for different kinds of files.)

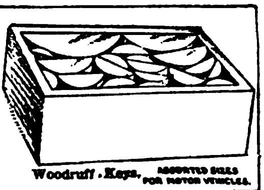
Reaming a Hole.

Take for instance a worn steering gear pin and eye (figs. 22-23). If new parts are not at hand then use a reamer.

If the reader has a stock of reamers, the best way is to ream out the holes. They can be filed out if the holes are shallow, but if there is a deep boss it is almost impossible to get a cylindrical hole. The best way would be to drill them out 1/32 inch larger or 1/16 inch if much worn, and turn the pins to this size, or fit a bronze bushing.

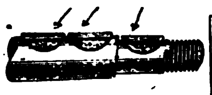
Great care must be taken in drilling the holes that the drill follows the old hole exactly, so that, if possible, the rods and jaws should be drilled together in place. Fig. 23 shows the drill having gone wrong. By far the best way would be to buy a reamer of the size required and make a really good job. Shake or play in the steering gear does not come on suddenly; there would be in most cases plenty of time to procure a reamer from the tool dealer. The reader must not forget when putting in new pins to insert the stop pin in the head or to drill the hole for the cotter pin. (see page 706 for reamers.)





Woodruff Keys, ASSORTED SIZES FOR MOTOR VEHICLES.

Woodruff Keys,



Keys.

There are three kinds of keys used on shafts; the square key, round and the half disk type, called the Woodruff.

The Woodruff key is used more on automobile work. They are the easiest to remove and apply, but when fitted, the shaft must be milled on a milling machine to take this key. (see fig. 26, chart 287A.)

The round key is seldom used because it is difficult to remove. If, however, a quick job is desired it is the quickest, as a hole can be drilled and the round key hammered in (not advised only on temporary work.)

The square key if applied properly can easily be removed.

Cutting a Key-Way.

For a square key the best method is by using a machine equipped for the purpose, however key-ways can be cut by hand as follows:

Key-way cutting with a chisel is an art that requires considerable skill. There are many men who can cut a key-way nearly as well as can be done by a machine, not so the amateur. The first thing to do is to mark out on the shaft the key-way required, with a line to show the center. It is best to have a few flat-bottomed drills and drill a series of holes in the shaft to the depth of the bottom of the proposed key-way. The holes should not be in actual contact, if they were so the drill would not bore straight. Then with a narrow cape chisel, chip away the intervening spaces and file with a small square file. As a square file is not an actual right angle at its corner, the angles of the key-way would be rounded off; therefore work these corners square with a saw file, but as a saw file is not cut its entire length (that is, has no teeth near the end), the end must be broken off to allow the file to work up to the ends of the key-way. The key must be of steel, fitted to bed down on the bottom of the key-way and tight at the sides. Keys of different sizes (in the rough) can be bought at tool shops. It will save time in fitting if a dozen or two are procured.

The key and key-way must be slightly tapered. The key-way will be found shallowest in the middle; this must be worked down, using the edge of a flat file.

A Drift.

Is used for many purposes. In this instance it is used with square keys.

If the shaft projects from the boss, a drift should be used to prevent damaging the key-way by the blows of the hammer. The drift (fig. 2) is a steel tool with a hardened nose. They are sometimes curved (note the dotted lines), as in many cases it is impossible to get a straight blow at a key. Care should be taken not to burr up the end of the key. A piece of heavy copper held over the end of the key by an assistant will prevent this.

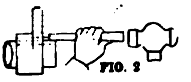


FIG. 2

Woodruff Key-Ways.

As stated on page 708, the key-way for a Woodruff key must be milled.

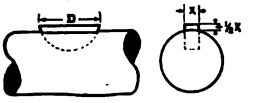
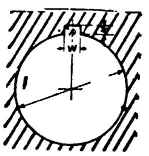


Fig. 26—Woodruff key-way

Fig. 26 shows a shaft that has been milled for a Woodruff key, with key inserted. "X" equals the thickness of key. The key should project above the shaft one-half its thickness.



Standard key-ways for pulleys and shafts; table 107 shows the recognized standard for the depth and width of key-way in pulleys. The same formula of course may be used for the depth and width of key-way in shaft.

Table 107.

Diameter (D) of Hole	Width (W) of Keyway	Depth (H) of Keyway	Radius (R)
3-8" to 9-16"	3-32"	3-64"	
5-8 to 7-8	1-8	1-16	030
15-16 to 1 1-8	5-32	5-64	035
1 3-16 to 1 3-8	3-16	3-32	040
1 7-16 to 1 3-4"	1-4	1-8	050
1 13-16 to 2"	5-16	5-32	060
2 1-16 to 2 1-2	3-8	3-16	060
2 9-16 to 3	7-16	3-16	.060

A list of the standard sizes of key-ways both for pulleys and shaft are given.

The radius (R) referred to, refers to the round corners on key.

To Remove Tight Stud.

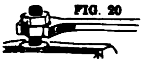


FIG. 20

Fig. 20: A method of removing a tight stud is to use two nuts and lock them, keeping wrench on lower nut.

Removing a Broken Stud.

Fig. 22: A broken stud or screw (S) can best be removed by a special left hand drill (D) called the "Ezy-out," mfgd. by Cleveland Twist Drill Co., Cleveland, O.

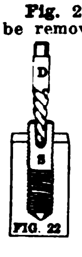


FIG. 22

Other methods are — pour kerosene around the stud to soak into the threads. If a piece of the broken stud stands above—the broken part may be removed with a chisel and hammer—not a sharp chisel, however. A diamond point chisel is best. If it will not move, then drill it out, using a drill well under size of thread. The hole should then be cleaned out with a tap, same size as thread. If in case of a **hardened set screw** which is broken, then use a blow torch and heat.

Another method—if broken part projects; saw a slot and use screw driver.

To Put an Over-Size Stud In a Worn Bolt Hole.

Use an over-size stud which will make a tight fit in top of cylinder stud bolt holes, then, either file, bore or ream hole out in cylinder head so it will take the over-size stud you are to use. For instance, if a 5/16 inch use a ⅜ inch tap and stud bolt. If a ⅜ inch use a 7/16 inch tap and stud bolt. If a ⅝ inch use a ¾ inch tap and stud bolt. The holes could be drilled out if you have no reamer. Straight reamer would be best. (also see Ford Supplement.)

To Remove a Tight Nut.

Try heating it if it cannot be budged with a wrench. Try pouring kerosene on the nut and bolt and leave stand for an hour or so. Drill holes in nut and split it with a chisel if it will not come otherwise. This will save the threads of bolt.

A Stripped Nut—Will Not Grip.

Usually the fine thread nut is the one which causes this trouble. A method that may be adopted is to reline the nut uniformly with soft solder and then give it a start on the bolt, and by working it down the thread a little at a time, cut a new thread inside the nut.

The soldering part of the operation is simple enough, the nut being fastened to a piece of iron wire, dipped in the killed spirits, and then held in the blow-lamp till hot enough to melt the solder. The same process reversed would apply equally well to a stripped bolt and nut used to cut a new thread on it.

A Simple Water Still.

When pure water is required for a battery and none is available, here is one method: The apparatus illustrated shows a teakettle, some garden hose and a jar for collecting the water. The water is boiled in the teakettle, condensed in the coils of the hose and caught in the jar. A copper coil of pipe is best, but not always available. A bottle of distilled water will last quite awhile for making up loss of evaporation—see page 455.

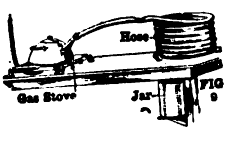
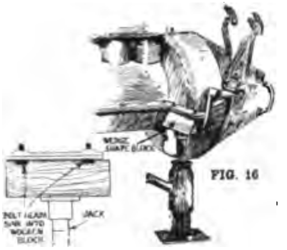


FIG 9


WEDGE SHAPE BLOCK
BOLT HEAD SAW INTO WOODEN BLOCK
JACK
FIG. 16

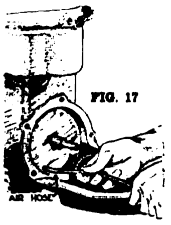


FIG. 17

Fig. 16. The four bolts on the front of the Ford transmission can be replaced by one man working alone, by inserting the bolts from under the car, laying a block of wood on top of a jack and lifting the jack till the heads of the bolts are pressed into the wood. This keeps the bolts in place and prevents them from turning while the nuts are put on.

Fig. 17. When the oil pipe T, page 197, of a Ford engine is clogged, remove the radiator and take off the front gear plate. The cam gear is then removed with a puller. This will expose the end of pipe and an air hose is connected to it and air turned on, blowing the clog out. This saves tearing the engine down. If pipe is clogged, gears will be noisy.

Fig. 18. Rear axle stand, made of wood. Note sliding base, which makes an adjustable stand.

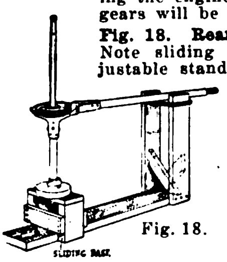
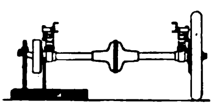


Fig. 18.

A device for straightening bent rear axle drive shaft, without removing. The bent part is turned as shown and then nuts tightened which draws shaft straight. Applies only to semi-floating axles and bends at end of shaft.



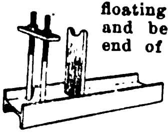


CHART NO. 287-A—A Drift. Woodruff Keys and Keyways. Removing Broken Studs and Tight Nuts. Miscellaneous.

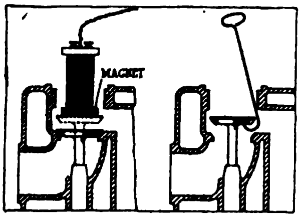
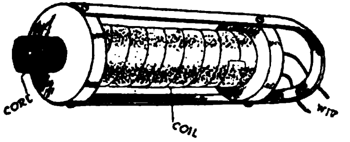


Fig. 1.—A magnetic valve lifter: Magnets have been used many times for picking up all sorts of iron and steel parts, but their use for pulling out valves is unusual. The magnet shown is approximately ¾x8 in. and is capable of exerting a pull of about 7 lbs., and will pull a valve out after springs have been removed.

A simple tool which will be found of assistance for removing valves that stick badly but may be raised a slight amount consists of a hook of Bessemer steel wire ⅛ in. in diameter.

Construction of the magnetic valve lifter: An old make and break spark coil forms the basis of the device. The core is made of a bundle of coarse iron wires. The outside of the coil is covered with tape and has a handle consisting of a strip of brass which extends down the sides of the coil to the end.



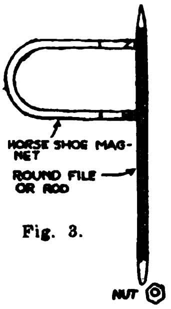
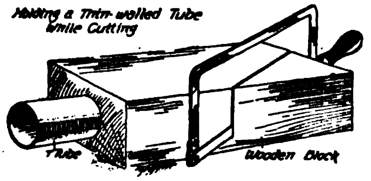


Fig. 3.

Fig. 3.—Another magnetic lifter — which is useful for removing a nut which may have fallen into cylinder or other inaccessible place is shown in illustration. Simply touching the file with the magnet makes a magnet out of the file (a long rod may also be used instead.)

Fig. 4—Method for sawing through tubing. Consists of a wooden block with a drilled hole to receive the tube. (from Newsabout Fords.)


Holding a Thin-walled Tube While Cutting
Tube
Wooden Block

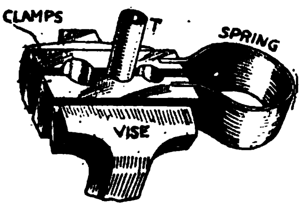
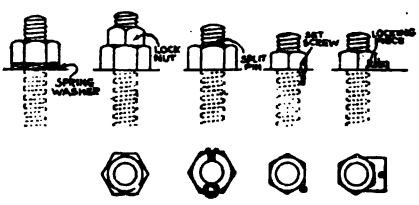


Fig. 5—Vise clamps for working with tubing. Note spring tension which keeps clamps in vise when jaws are opened.

Fig. 5.



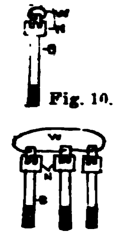
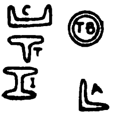


Fig. 10.

Fig. 9—To prevent nuts from coming off, various locking devices are employed. First one to the left is the well known and most used lock washer. The next one is used a great deal also, that of using 2 nuts. By holding the top one and backing off the lower one slightly, the nuts are securely locked. The next one is also used a great deal in connection with castellated nuts. The other two methods are used extensively by the Navy department (absolutely sure, but expensive.) The lower cuts show a plan view of the various locking devices directly above.

Fig. 10—A stud locking method: It sometimes happens that after securely locking the nut on a stud, the stud unscrews itself at the other end and is lost. When wired as shown in lower cut, this is prevented.

Fig. 11—You have often heard of I-beam front axles and pressed channel steel frames, channel iron, T-head, etc.



C—End view of a channel section.
T—End view of a T section.
I—End view of an I beam.
A—End view of an angle iron.
TB—End view of a tubular section.

Note—Mostly spoken of as "section"; meaning cross-section or view from end after being cut in two.

***Fig. 17—A spark plug and lamp testing outfit** illustrated below is handy for carrying from one part of the shop to another, for testing on different cars. Several dry cells are placed in a long, narrow box, and connected through a double-throw switch to the testing terminals. One side of the switch throws the two types of lamp sockets (single and double contact, see page 433) into the circuit, and the other side connects the batteries through the spark coil to the plug testing rests. This unit is compact enough to be taken directly to the job.—(Motor World).

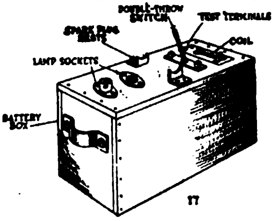
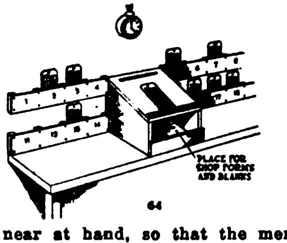


Fig. 64—A foreman's desk: System is essential in the repair-shop, but because it is system does not necessarily require an elaborate equipment . An old packing box may be made into a foreman's desk, and a few strips of wood and tin may be used to construct a workmen's time and work card filing rack. The blank cards are always available, and clean. Any of the workmen's cards may be seen at a glance, and are in order. A clock should be hung near at hand, so that the men will not have to guess at the time—(Motor World).


PLACE FOR SHOP FORMS AND BLANKS
64

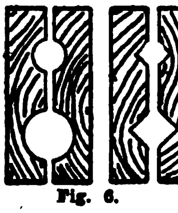


Fig. 6.

Fig. 6.—Vise clamps made of wood, ⅛ inch sheet copper and sometimes sheet lead. Are useful and necessary where material is to be clamped in vise, which would mar its surface otherwise.

When vise clamps are made of sheet copper or lead—use ⅛ inch thick—cut to size of vise jaws and bend over top of jaws to support them in place.

Wooden clamps made of hard wood with holes bored through and then saws across, about ¼-inch or more being cut away; or they can be cut to a V. These latter will take bars or pipes of various sizes without injury.

T NO. 288—Miscellaneous Shop Hints.

es 418 and 424, for other Electrical Testing Outfits, also 864-H, I, J and K.

How to Make Lathe Tools.

***High speed steel,** usually, should be heated until the tip of the tool starts to melt, and then plunged in oil, or buried in common salt until thoroughly cool. **High carbon** steel gives the best results when heated to dull red and plunged in oil.

Only the tool point proper should be heated to the plunging temperature, the heat applied slowly at first and then the blast turned on and the point heated to the required plunging temperature.

The tool should be plunged into the oil when the heat is increasing, and at the instant the point reaches the plunging temperature—dull red—in the case of carbon steel; fusing in the case of high speed steel. This is particularly necessary with high carbon steels, as heating the steel white hot, allowing it to cool to dull red and then plunging it in oil will make a poor tool.

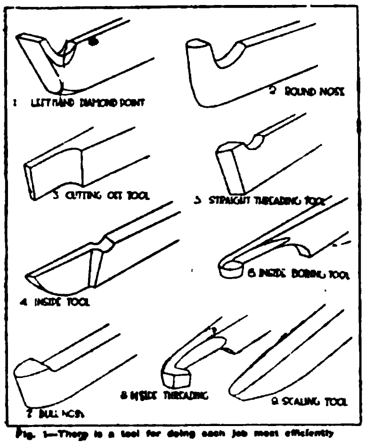


Fig. 1—There is a tool for doing each job most efficiently

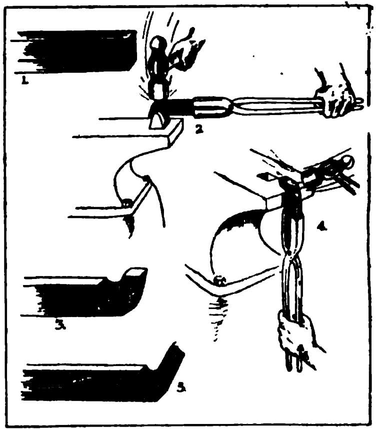


Fig. 2—Steps in making a lathe tool. The work should be done during one heat.

High speed steels, after hardening and grinding, are ready for use. Carbon steel tools, however, must be tempered.

This may be done in two ways, the best being to plunge only the point of tool in oil after heating to dull red, thus leaving some heat in the heel of the tool.

When the point is black, remove the tool and rub the cutting edge with emery paper mounted on a stick. Watch the point closely and as the heat is driven from the heel to the point, the color of the surface being polished will turn light straw, dark straw and blue.

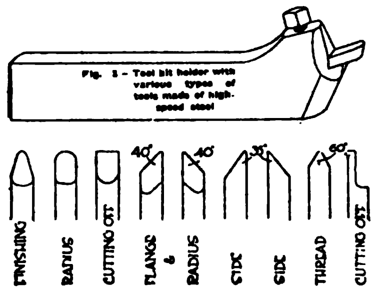


Fig. 3 – Tool bit holder with various types of tools made of high-speed steel

When the point of the tool is straw color plunge the whole tool in oil and cool it entirely. The other method of tempering is to cool the tool after the first heating, polish the point, slowly heat it again until straw color, and then plunge it.

Almost any grinding wheel may be used for grinding the tool, but care must be taken not to draw the temper, or burn the tool. The tool should be held lightly against the wheel and frequently cooled in water. Grind the tools to the shape desired, following closely as possible those illustrated. Finish the cutting edges with an oil stone.

Fig. 3 shows a tool bit holder and standard set of high-speed tools. These are excellent for repair-shop purposes, though expensive. The shapes illustrated will cover a great variety of work, and the tool should be changed to suit the work, rather than regrinding the tool each time.

How to Solder.

A soldering copper (fig. 2) is a wedge-shaped block of copper, fitted in an iron fork with a wooden handle. To use, it is placed in a clear fire, or gas or blow pipe torch (fig. 1) burner till it is hot enough to use.‡

If the copper is a new one, it must be tinned. When hot, file off the scale on both sides and ends for a quarter of an inch from the tip, so that the metal be clean and bright, dip the nose in the soldering fluid for a second, and then apply it to the stick of solder. A globule will melt off on to a piece of dry brick or tinplate which must be ready to receive it. Rub the nose of the copper in this solder, which will adhere to it as quicksilver does to zinc. The copper can then be used.

How to solder: To solder two surfaces they must be clean and dry and rubbed with emery cloth. Old work may require cleaning with hot water and soda to remove the grease, and the solder runs along the joint and binds the two together. To clean the metal and allow the solder to work freely, a flux must be used. †Solder—the melting point of soldering material must be lower than article soldered. (see page 539, melting points.)

***The soldering acid generally used** is made by placing a few bits of scrap zinc in a few ounces of commercial hydrochloric acid (spirits of salt) or muriatic acid. Drop the zinc into the acid a little at a time, violent boiling occurs, and as the fumes given off are injurious to the lungs, and also attack any bright metal work, the jar should be placed in the open air. Add zinc until the boiling ceases, and the fluid can then be used. There are several soldering fluids sold, some in the form of liquid and some in the form of paste.

For electrical work use resin as resistance is set up in a joint soldered with acid.

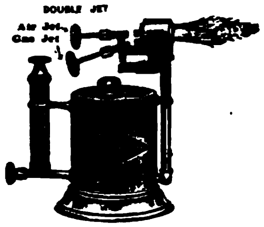


Fig. 1—A Blow Torch. Very useful around any shop.

Fig. 2—A soldering iron also called soldering copper

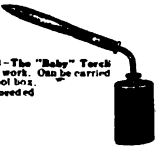


Fig. 3—The "Baby" Torch for light work. Can be carried in the tool box. No air needed

The soldering copper must not be allowed to get red hot, as the tin will be burnt off and the tinning process must be repeated. The reader should practice soldering at leisure, so that when he requires to use the bit for work on the car, he should know how to do it. For practice, he will very likely find some leaky water cans in the house or in his garden. If a can has a bad hole in it, a patch must be put over it. But he must remember that the surface must be perfectly clean. Sometimes, especially in old work, the emery cloth will not get a clean surface. A dark spot may be a depression which the emery cloth will not reach; the file must then be used. No soldered joint should be exposed to a great strain.

†Hard soldering or brazing is a term used when the soldering mixture is composed largely of copper, brass, or silver. Use borax for flux. Hard soldering is best, where material will stand intense heat.

****Soft soldering** is the ordinary half and half (½ lead and ½ tin.) Plumbers solder has 2 parts lead to 1 of tin, and is therefore still softer than half and half, due to working on lead pipe.*

CHART NO. 289—How to Make Lathe Tools. (see also chart 247-G). **How to Solder.**

*A solution of salammoniac and borax also makes a good soldering fluid, working equally well in copper or bra

‡See page 735, "how to operate a blow pipe torch." Above torch is a "double-jet" type. See page 696 f a gas heater. **See pages 715 and 789 for solder for radiator repairing known as "50-50" solder.

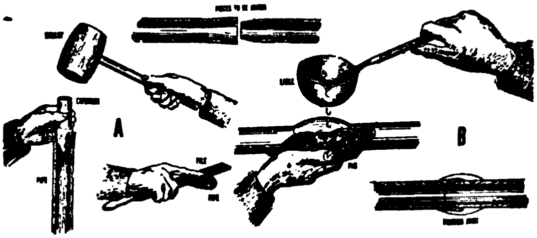


Fig. 1—Preparing to join two pieces of pipe and method of wiping a joint.

Wiping a Joint.

Joining two pieces of lead pipe—called "wiping a joint." The pipe is first cleaned and prepared, by spreading one pipe as at (A) and pointing the other and ends slipped together, as shown. The solder is melted in a ladle and is poured around the joint. A pad of canvas or velvet is held in the hand under the pipe, as shown, the surface of this being well greased with tallow. It need not be more than three or four inches square and about one-quarter inch thick, and the bottom layer may be of asbestos sheet so that there will be no possibility of the molten metal burning through and injuring the hand of the operator.

As the molten solder is poured on the pad, it is wiped around the joint until it is heaped up all around the point of junction, the amount of metal used depending upon the size of the pipe or tubing joined. As the metal is applied and wiped smooth with the pad before it has a chance to harden, the finished joint has a neat appearance. Note—Rub the pipe on each side of the joint with a tallow candle and the metal will not adhere where it is not wanted.

While copper or brass pipe may be joined without difficulty by ordinary methods of soldering or brazing, the wipe method is about the only practical way to couple lead tubing.

Gasoline Feed Line Repair.

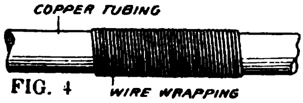


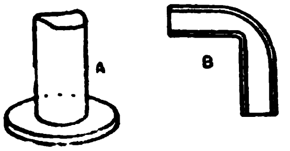
FIG. 4

A broken gasoline feed line may be quickly repaired by scraping the tube near the break, and winding it for 1 in. each side with clean copper wire. The wire should then be heated, covered with soldering flux, and sweated together with solder. A solid sleeve is thus formed that makes the pipe stronger than originally.

Gasoline pipes sometimes get loose in the sockets of the unions. This is due to bad fitting, and shows there is not sufficient elasticity in the pipe; it is too rigidly held. The screwing up of the union strains the pipe and the vibration on the road causes the pipe to give way at its weakest point, namely, the soldered joint. If the pipe gets loose more than once, it shows there is something wrong. A longer pipe should be put in, having a U bend in it or a complete circle to give elasticity. The U bend or circle should lie horizontally, with a drop towards the carburetor; otherwise there may be what is called an air-lock, in the pipe, and the gasoline will not pass through. (see page 192, for principle.)

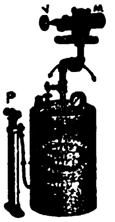
If the carburetor float leaks, (if of metal) it can be repaired with solder. Sometimes it is difficult to find the leak, for one method of locating it see page 167.

Brazing a Flange.



If it is desired to braze a flange on to a pipe, the flange is placed on the pipe and the pipe expanded by hammering till it is a tight fit. This is necessary, as it may shift its position in the act of brazing. The flange and pipe (A fig. 2) are put in a clear fire in the forge. Then as it gets hot the spelter, with borax, is sprinkled round the joint, which melts and finds its way into the space between the pipe and the flange. If the reader has a gas or gasoline blow pipe it will make the work easier, as the heat can be directed where required from above. When cool the superfluous brass is filed off. In many cases it is impossible to keep the two pieces of metal in the correct places in the forge, therefore a pin or rivet must be put in, so that they cannot shift.

For tube bending see next page.



Brazing Torch.

*A gasoline brazing torch, for brazing, pre-heating and general work. Principle of operation is similar to that explained on page 735 of a blow pipe torch, except tank and burner (M) are larger. 75 lbs. of air is put into tank by hand pump (P). The tank is a 10 gallon capacity.

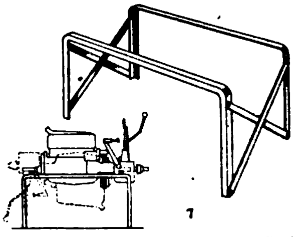


Fig. 7 — Another engine stand: This is a simple engine stand that will take almost any engine. It is 2 inch angle iron, bent into a U-form and fastened together by cross braces. The engine side arms rest directly on the stand, but a cross bar must usually be fitted under the front of the engine to hold it in place. This stand may also be used for rear axle and gearbox work—also see pages 605 and 648.

A Pocketed Valve.

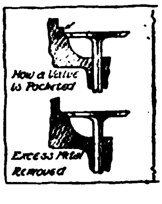


Fig. 8—Remedying a pocketed valve: When the engine begins to lose compression, one of the first things to be looked at are the valves. If the exhaust valves have become pitted, they must be ground in with emery and oil. This process, while it furnishes a ready remedy, when often repeated, will take away a portion of the valve seat. Thus the valve will be lowered and lowered, until finally it is "pocketed," and much power is lost because the valve does not open soon enough, although the timing might be correct. This difficulty may be overcome by cutting away the excess metal, as shown in illustration, thus restoring the valve to normal conditions. (Newsabout Fords.)

HART NO. 290—Wiping a Joint. Brazing a Flange. A Home Made Crane. Remedying a Pocketed Valve. Another Handy Engine Stand.

*Clayton and Lambert, Detroit, Mich., manufacture brazing outfits. Also Imperial Brass Co., Chicago, Ill. See page 696 for gas heater.

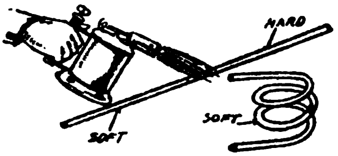


Fig. 4—Annealing copper tubing.

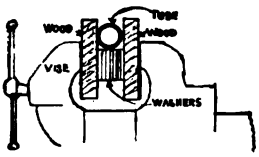


Fig. 5—Form for bending tubing.

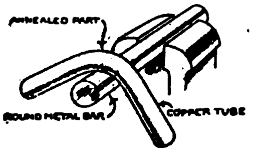


Fig. 6. Fig. 7

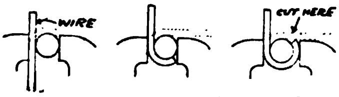
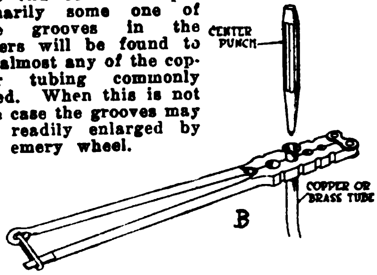
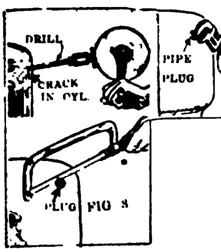


Fig. 11—To bend wire or rods.

Fig. 12—Flanging copper tubing; Copper tubing may be readily flared for the attachment of unions by the use of a pair of lineman's splicing pliers. The end of the tube to be flanged is caught in the jaw of the pliers and a punch used to press the end out the required amount. Ordinarily some one of the grooves in the pliers will be found to fit almost any of the copper tubing commonly used. When this is not the case the grooves may be readily enlarged by an emery wheel.





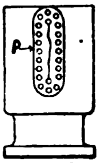


Fig. 16.

Annealing.

Fig. 4—Annealing: The tubing used for gasoline, gas lighting etc. is usually of copper and is usually hard. It is difficult to bend it when hard. The tubing can be softened by heating as shown in fig. 4 (called annealing.) Iron rods and other metals of like nature can also be softened by annealing.

Bending Metal Tubing.

The problem of bending metal tubing is one that come up quite often in the motor-vehicle repair and construction shop. Often when you undertake to bend some of the new kinds of metal tubing you are surprised to have it break, even though the usual precautions may have been taken to prevent a fracture of this nature. Fill the tube with fine sand packed tight, otherwise the walls are very liable to break or they are liable to collapse.

First of all, it is best to determine the character of the composition of the tubes. Many tubes of different manufacturers are made and finished nearly alike and you cannot very well determine what procedure to follow when desiring bends or scrolls in the same. But the file test will quickly remedy this. Or even the point of a cold chisel will do to determine the nature of the metal, then you can work accordingly.

Fig. 5—Bending small tubing: It is well to anneal the tubing first. Then procure several washers, and place side by side until thickness of tubing is obtained. Two wood blocks are placed one on each side and clamped in the vise. The blocks serve as guides. The tubing is then bent by hand over this form.

Fig. 6—Another plan to secure a uniform bend is to employ an outside mandril on the tube. This consists of a closely and tightly-wound spiral of iron wire of about 14 gauge over the tube. This distributes the stresses in the operation of bending, and afterwards it can be unwound. Small bore tubing can be bent by placing a piece of copper wire (a fairly good fit) inside and withdrawing it afterwards.

Fig. 7—To bend small rods and yet leave it circular in form: Drill a hole in a flat piece of iron, fix this in a vise, heat the end of the rod—having previously marked the place where the bend is to be—insert the hot rod in the hole and bend down, using the hammer to ensure a right angle turn, not a curve. The hole must be larger than the rod or the hot end will not enter.

Repairing a Cracked Cylinder.

Repairing a cracked cylinder: Welding is best, but if this isn't convenient a crack can be repaired with copper as follows:

Fig. 16—A small hole should be drilled at each end of the crack or a little beyound it, for the crack may go further than is visible to the eye. A ¼ inch hole should be drilled and tapped, and a screw inserted and screwed home, and the end filed off flush with the metal. Then a piece of stout sheet copper (P) (not less than 1/12 inch thick) should be cut out covering the crack extending about ¾ inch all around. This must be bent to fit the cylinder and fixed down with a number of 3/16 inch or ¼ inch screws. Put a piece of canvas smeared with red lead, putty, or thick oil paint under the copper. The patch may leak a little at first, but will probably "take up" in a few days.

Plugging is another plan: A very small crack in a cylinder, probably caused by freezing of contained water, may be mended as follows. Drill a small hole in each end of the crack, and tap it for a small copper plug (fig. 8.) Scrape the surfaces near the crack until the metal is bright. Cover the crack with soft copper filings and melt them in with the blow torch. Use a flux of rosin dissolved in alcohol, or simply drill and thread the hole, if not too large and screw in a pipe plug tap and saw it off.

Rusting up a small leak in a cylinder; ¼ pound of sal ammoniac to 1 quart of water poured into cylinder and left stand for 48 hours has caused rust enough to form to entirely close a small hole. Be sure and wash out thoroughly. Another remedy is an "iron cement" secured at supply houses. Cider or vinegar will cut rust out of cast iron cylinder water jackets, if left standing for two or three days.

How to Use the Metal Saw.

The fine-toothed blades should be used for iron and steel and the coarser ones for brass and soft metals. For cutting through a brass or steel tube use a fine-toothed blade, as the teeth rip off the coarse ones. Before sawing make a true circumferential line round the tube where the cut is desired; then, by turning the tube round a little between each cut, the latter will be true and square. The broken blades are useful at times for small repairs, as they are readily softened.

Spiral springs; are so readily obtained in a large variety now that it is not often one is at a loss for a particular size of spring. The occasion may arise, (and it is worth keeping in mind) that the hand drill fixed in the vise makes a first-rate winder for small springs, using a piece of round steel rod as a mandril.

CHART NO. 290-A—Annealing. Tube Bending. Repairing a Cracked Cylinder. Flanging Coppe Tubing.

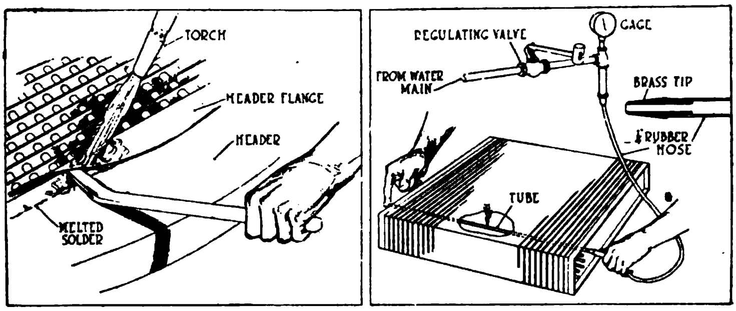


Fig. 1—Left—Removing the header from the radiator body is done by heating the soldered flange only, and as the solder melts a bent screwdriver is used to pry the flange loose. Fig. 2—Right—Radiator testing stand

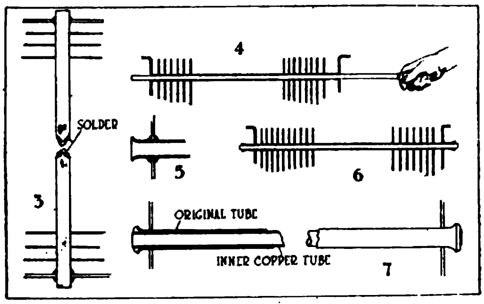


Fig. 3—Left—Method of cutting out a leaky section and soldering up the tubes. Fig. 4—Upper—The tubes are cleaned by running a rod through them. Fig. 5—Center—The ends of the tube are made bell-mouthed with a prick punch. Fig. 6—Right—Another tube is slid inside of this one. Fig. 7—Lower—The projecting ends of the two tubes are soldered together

Rebuilding a Radiator—(Cadillac as an example.)

Three Methods Available.

Radiator repair is one of the least understood jobs in the repairshop, yet one that is often necessary. Carelessness on the part of the driver either in letting the water freeze or in running into something, is about the only thing that will cause a radiator to leak.

Three methods of repair are commonly used. The first is to place some sort of a compound in the radiator, sealing the leak. The second is to force the fins to one side, exposing the leak, and soldering it up. The third, in the case of a split tube, is to cut out that portion of the tube that is leaky, and solder up the ends, fig. 3.

The first method should be avoided. Though only a few tubes may leak, the compound affects all tubes alike, impairing their efficiency. The amount of compound to be used is usually left to the discretion of the workman and too much of it may seriously affect the proper cooling of the water.

The second method is the best of the three and is practical for any number of leaks.

The third method is also practical when not more than 2 or 3 per cent of the tubes are affected. It is important that the tube be cut and soldered at the top of the tube as well as just below the leak.

Rarely, however, are one or two tubes alone injured, and the method herein outlined is to be recommended. In short, it is to tear the radiator down, removing the top and bottom headers and expose the tubes, find the leaky tubes, and to solder an inner tube into them, closing all leaks. After this the radiator is assembled.

To do the job efficiently, a certain amount of equipment is necessary. The first is an oxy-acetylene welding outfit having a torch fitted with the smallest possible tip. This is used to melt and remove the headers, and again in rebuilding the radiator. A common gasoline torch cannot be used, because the flame is not concentrated, and would melt the solder holding the tubes in place when the headers are being removed.

A properly constructed testing device must be used. The one illustrated is suitable. Water pressure is used and the leak determined. The water is taken from the pipe line, through a regulating valve that steps the pressure down to about 15 lbs., as shown by a pressure gage. Ordinary city pressure should never be used for testing without a regulating valve. A greater pressure than 15 lbs. might burst a tube and 10 lbs. is as much as should be used in testing the top and bottom headers. The water is carried through a rubber tube to the tube to be tested, the end of the rubber tube being fitted with a brass tip to facilitate insertion in the tube to be tested.

Substitute for Regulator.

Where a pressure regulator cannot be used with a city water supply, a simple pipe may be run up through the second story or roof and a sufficient head for testing be obtained by filling this with water. Each foot of head would have about half a pound pressure, or to be exact, a 23 ft. head would furnish a pressure of 10 lb.

All of the radiator tubes must be cleaned and straightened to permit the insertion of the inner copper repair tubes. This is done by running a length of 7/32 in. rod through the tubes. This rod is mounted on a file handle, as shown in fig. 4

The copper tubing used in making this repair is extra thin, 7/32 in. outside diameter tubing, and may be purchased from any jobber. It is somewhat expensive, but inasmuch as a small amount of it may save a whole radiator, its use is really economical.

The balance of the necessary tools comprise a knife, center punch, emery paper, soldering paste, solder and a light hammer. Then, having the equipment, tools and idea of what is to be done, this is the way to do the job.

How To Do It.

1—Drain and remove radiator.

2—Place it face downward, and using the oxy-acetylene torch, unsolder the lugs holding the shell to the body, and remove the shell.

3—Still using the torch, heat the lower header flange and pry it loose from the header with a bent piece of thin iron (see fig. 1). The flame must be concentrated on that part that is hanging, and the flame should not be held too long in one place or the solder holding the tubes in the header may be melted. It is not an easy job to remove the header, and the work must be carefully done, so that neither the flange nor the header is injured and may be soldered together again.

4—In a similar manner, remove the top header. Both ends of the radiator tubes are now exposed.

5—Using the rod as shown in fig. 4, clean out each tube, one by one. This should be done before the testing, as the solder from some previously repaired leak may be removed, causing a leak.

6—Place the radiator on the testing stand, as shown in fig. 2, and test each tube, one by one, determining whether or not it leaks. If a leak is found, mark that tube with a V made on the header plate with a knife.

7—Replace the radiator on the soldering bench.

8—Make both ends of all the leaky tubes bell-mouthed, as shown in fig. 5, using a center punch as an expander.

9—Scrape the inside of the bell-mouthed tubes clean and bright with a knife.

CHART NO. 290-B—How to Repair a Radiator—Cadillac as an example. (Also see page 194 and hart 290-C, page 789 and Index.)
(Motor World.)

—Continued from chart 290-B.

10—Slide the thin 1/32 in. copper tube into one of the leaky tubes, until its end projects about 1/16 beyond the bell-mouthed end of the leaky tube. see fig. 6.

11—Cut the other end off so that it projects 1/16".

12—Repeat with each of the leaky tubes.

13—Apply the *soldering paste to the tube ends, and using a concentrated oxy-acetylene flame, heat the tip of the thin inner tube, and the bell-mouthed tube, and run solder into joint as shown in fig. 7.

14—Repeat this with each tube end, taking care not to melt the solder holding the original tube to the header end plate.

15—Straighten and clean the header flanges.

16—Replace the upper header, and carefully solder it to its header flange.

17—Replace the lower header, and solder it to its header flange.

18—Plug all inlet and outlet holes in the radiator, and test under 10 lb. water pressure.

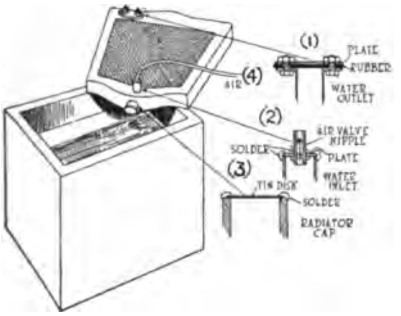
19—Replace the shell, and resolder the lugs.

20—Replace and refill.

In using this method it should be remembered that the tubes repaired by inserting the thin inner tubes are not as efficient as the original tubes because there is no fused metal contact between the inner tube and the fins of the radiator.

There is therefore a limit to the number of tubes it is practical to repair in this manner.

†Testing and Soldering Radiators.



Method for Testing a Radiator (Packard as Example.)

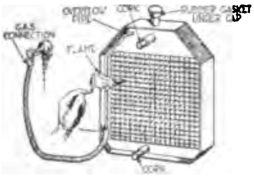
The radiator is removed from the car, and all inlets and outlets sealed. The filler opening is closed by a metal cap, soldered on; the outlet closed by a plate bolted to the flange, and the inlet closed by a soldered plate bearing an inner tube air valve. Air pressure may now be applied to the radiator, after immersing it in water. Bubbles locate the leaks immediately, after which the leaks are soldered, and radiator tested.

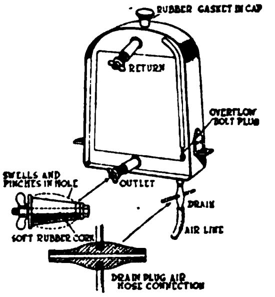
Marking Leaks in Radiators.

When testing a honeycomb radiator for leaks the position of the cracks as indicated by the bubbles may be marked by placing split rivets at every point, where leakage occurs. By this method no time is wasted in looking for the defective spots when soldering.

Testing with Gas.

Testing by air pressure is liable to place a dangerous strain on the tubes and dipping in water is necessary in order to locate the leaks. By using city gas these difficulties may be avoided. The inlet, outlet and filler opening are plugged and the city gas passed into the radiator through the overflow. When a lighted match is passed over the tubes, the location of any leak is immediately shown by a flame.





Another Radiator Test.

All openings of the radiator must be plugged before air pressure is applied, to test for leaks by immersion in water. Ordinarily this is done by soldering up the openings. By the method illustrated all the openings may be stopped. The filler opening is closed tightly by placing a rubber gasket beneath the filler cap, and screwing it in place. The inlet and outlet are stopped by rubber corks, that are inserted, and then expanded by squeezing them together with thumb screws. The overflow is stopped by screwing a tapered cap screw into it. Air pressure is applied through a special nipple, one end of which is screwed into the drain plug hole and the other attached to the air line.

Removing a Leaky Section.

Honeycomb radiator repairing is exceedingly difficult, at the best, but a simple method of repair is illustrated. The leaky section is entirely removed, and the water passages entering into all sides of the resulting opening are soldered up. After testing, a dead section is inserted in the opening, and its edges soldered to the edges of the opening. Though the cooling capacity of the radiator is somewhat reduced, the job is permanent.

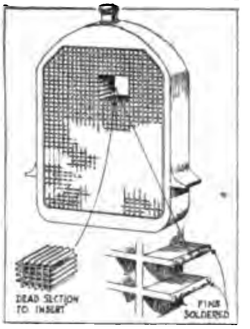
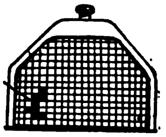


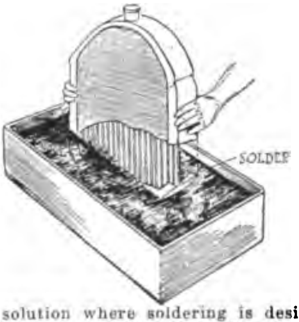
Fig. 3—The leaky section is cut out, the edges soldered up to prevent leakage, and then a dummy section is soldered in place

Cold Solder.

For repairing leaks temporarily by pasting in the leaks. Solder hardens on exposure to the air. Mfg'd by Stone Solder Co., 3107 Detroit Ave., Cleveland, O.



Soldering by Dipping.



Dipping is a quicker and more satisfactory way to solder the tubes of a radiator in place. The objection to the use of the soldering iron is that the tubes are so inaccessible that it is difficult to solder, and if a blow torch is used, there is danger of melting some of the joints previously soldered. The ideal method is to provide a solder bath. The parts to be soldered are thoroughly cleaned and treated with muriatic acid solution where soldering is desired, then the radiator dipped. The solder naturally will adhere only to the parts that are clean. **The solder is made of 50 per cent lead and 50 per cent** bar tin melted together.

CHART NO 290-C—Radiator Repairs—continued. See also pages 714, 194, 584, 789. (Motor World.)

Slight leaks in radiators and even a crack in the water manifold can be stopped by use of some of the radiato cements circulated in the water system. Some of the manufacturers of radiator cements are Woodworth Mfg Corpn., Niagara Falls, N. Y.; X-Laboratories, 630 Washington, St., Boston, Mass.; N. W. Chemical Co., Marietta, O

*See page 711 for muriatic acid soldering solution; how to mix. †See advertisement, back of book, for th Continental Radiator Stand, for holding radiator to work on.

Cutting Gaskets.

Perhaps one of the first things at bench work a young repairman is taught on entering a shop is that of cutting gaskets.

The gasket between the base of cylinders and the crank case and the cover of gear box, are usually made of paper.

If care is not exercised in removing a cylinder from the crank case, the paper washer or gasket may easily be damaged by part of it adhering to the cylinder and another part to the crank case. Should the gasket by chance be ruined, a new one can easily be made in a few minutes.

Cutting cylinder head gaskets: A sheet of fairly heavy wrapping paper should be obtained and a hole made just large enough to accommodate the piston. The paper is then rested on the crank case and with the aid of a ball-poen hammer tapped all around the edges of the crank case. It is, however, best to first mark the holes for the holding down bolts and inserting the latter to hold the paper in position.

When making the corners and also the holes for the bolts it is best to use the poen or round end of the hammer.

It is not necessary to strike the paper a hard blow, only a series of slight taps being required when it will be found that the gasket will have a niece clea. cut edge and conform exactly to the desired shape.

It does not matter much how complicated the shape of the gasket may be for if the above suggestions are followed, making a new one will be comparatively simple.

The hardest part of the whole procedure is to keep the paper in place on the crank case, but if the holes for the holding-down bolts are first made and then the bolts inserted as shown in the illustration, no difficulty should be experienced.

After the gasket is finished it should be covered on one side with shellac and allowed to dry a short while. Then when the nuts are tightening up a good oil-tight joint results.

Cutting gaskets for gear box cover: The same principle applies.

Be careful in tapping so that the edges will not be broken. Sometimes it is possible to press the paper by hand and make indentation enough to cut the gasket from.

Other gaskets, such as mobolene and asbestos gaskets are made in similar manner, but are usually marked off by pressure of hand or finger, when placed over the part to be fitted, then cut out with a sharp knife. Asbestos gaskets for cylinder heads are sometimes made when nothing else can be had. It is soaked in linseed oil before applying.

Shellac.

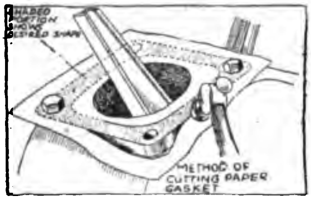
Shellac is an excellent preparation to insure a good tight joint and ought to be used on only one side of a gasket. Shellac dries up, but a good way to handle it is to have a wooden stopper which can be used for applying the shellac as well as acting as a stopper.

When a workman wishes to spread a coat of shellac upon a gear-case cover, or a gasket, he has but to invert the bottle with the stopper in place, then remove the stopper and roll the large end over the surface to be smeared, and a coat of shellac is left in its wake.

How to mix shellac: Secure an open mouth bottle, fill nearly full of flake shellac and pour in alcohol, and let it dissolve. This will make a very thick solution. To make it thinner put in less flakes of shellac. The flakes can be secured at any drug store.

Using shellac: In replacing detachable cylinder-heads, only the smallest possible amount of shellac should be used and this should be quite thin. If the shellac is heavy and any considerable quantity is used it will squeeze out into globules and the first explosion will blow these into the valve ports, where they will start an accumulation of carbon.

Note—When using shellac on a gasket, use it on but one side. The gasket can then be used over and over again. Otherwise it will be necessary to make a new one each time removed. Common grease is used by many to hold gasket in place until part is placed in position and drawn up.


SHADED PORTION SHOWS DESIRED SHAPE
METHOD OF CUTTING PAPER GASKET

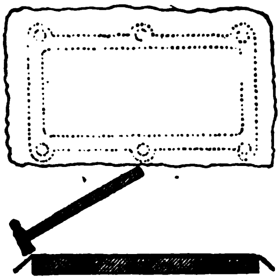
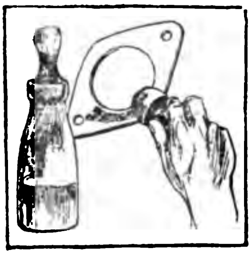
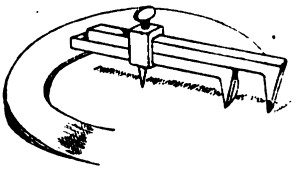


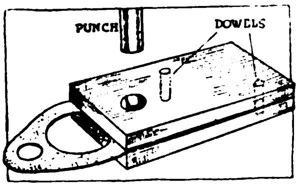
Fig. 2—Cutting a paper gasket for transmission cover.



A bottle of shellac is needed in every repair shop.

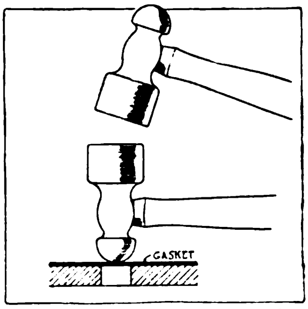


A device for cutting circular gaskets may be made out of two pieces of steel shaped as shown and fitted with a clamp which forms the center. The two cutting members are adjustable, so that practically any size of gasket may be cut.



It is difficult to cut holes in gaskets and not have ragged edges. When there are a great many holes of a given size to be made, it is advisable to construct a die consisting of two plates of metal doweled together and with a hole or series of holes through which the dies may be pushed. The gasket material is slipped between the plates, and then the die is forced through with a hammer

Another method is to file a chiseled edge on short sections of different size iron pipes which can be used as punch cutters.



When cutting gaskets from metal and asbestos packing, felt and other materials it is sometimes difficult to cut bolt holes, especially those close to an edge, without damaging the material. A way out of the difficulty is to use two round-headed hammers, placing the round head of one over the hole and striking it with the other.

Packing for Water Pumps and Lubricators.

Packing for water pumps and lubricators: For all packing joints nothing has been found better than **asbestos string plentifully** smeared with a mixture of heavy oil and graphite. Candle wicking can also be used if asbestos string is not handy.

Ball bearings for cutting small holes: Ball bearings of various sizes are useful in cutting small holes, such as for studs, in gaskets. After the gasket is cut to shape by hammering around the edge of the gasket flange, a ball bearing is put over the hole and hammered until the hole is cut in the gasket. This method produces sharply defined edges. In cutting paper gaskets it is advisable to grease the paper first so that it will stick to the surface.

CHART NO. 291—Cutting Gaskets. How to Mix Shellac and How to Use it.

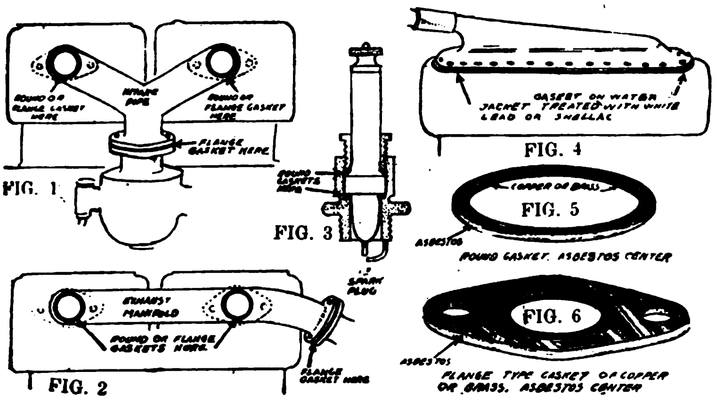


FIG. 1
ROUND OR FLANGE GASKET HERE
INTAKE PIPE
ROUND OR FLANGE GASKET HERE
FLANGE GASKET HERE
FIG. 2
EXHAUST MANIFOLD
ROUND OR FLANGE GASKETS HERE
FLANGE GASKET HERE
FIG. 3
ROUND GASKETS HERE
SPARK PLUG
FIG. 4
GASKET ON WATER JACKET TREATED WITH WHITE LEAD OR SHELLAC
FIG. 5
COPPER OR BRASS
ASBESTOS
ROUND GASKET. ASBESTOS CENTER
FIG. 6
ASBESTOS
FLANGE TYPE GASKET OF COPPER OR BRASS. ASBESTOS CENTER

Showing the different places where the round and flange type of gasket are used.

Gaskets—Different Kinds.

Gaskets are used on the engine and gear-box and other parts of the car. The purpose being to make tight joints. Thin gaskets are preferable to thick ones and should always be used on all joints that come together square. Metal to metal joints are best, but it is next to impossible to make both flanges meet absolutely square. It is for this reason that some sort of flexible material is interposed to make up for the inequalities in material and workmanship.

On the engine, gaskets are used in such places as the gear case cover in front of engine, water plate on cylinders, on the intake and exhaust manifold, spark plugs, etc.

On the gear case, a gasket is usually placed between the cover and gear box to prevent the oil from working out.

The housing cover on differential is sometimes fitted with a gasket, but more generally it is simply given a coat of shellac.

There are several kinds of gaskets; the paper, asbestos, asbestos wire lined, copper and in the absence of copper-asbestos lined gaskets—lead can be used.

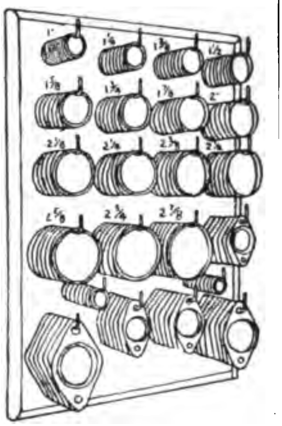
The copper or brass gasket for such places as the intake and exhaust manifold are usually made of copper or brass with asbestos interlined. They are made either round or flange shape. Copper gaskets are also used between the water plates or pipes on cylinder. These gaskets can be bought ready made.

Flange shaped copper or brass gaskets are also used between the carburetor and intake pipe. (Lead or leather can be used, also mobolene.)

Asbestos gaskets are made of closely woven, long fibre asbestos yarn and brass wire closely woven and impregnated with a heat and water resisting compound. The red compound on one side sticks to flange when joint is broken. The graphite on the other side allows joint to be easily taken apart. Sold in rolls or in gaskets cut to order. This is used in many places, such as the water plate, but it is usually used where there is a great deal of heat. If sheet asbestos (not wire woven) is used, it ought to be soaked in linseed oil.

Paper gaskets can be used in many places. For instance the plate cover for gear box and between cylinders and crank case. In using paper select a heavy wrapping paper and shellac it well on each side when applying.

Paper of light cardboard weight can also be used for the water plate on cylinders but must have shellac on each side.



Board measures 17x26 ins., has 26 hooks and holds 650 gaskets of the following; sizes:

Round Closed Type Gaskets.
Fig. 5.

25—1 -inch I. D
25—1⅛-inch I. D
25—1¼-inch I. D
25—1⅜-inch I. D
25—1½-inch I. D
25—1⅝-inch I. D
25—1¾-inch I. D
25—1⅞-inch I. D
25—2 -inch I D
25—2⅛-inch I. D
25—2¼-inch I. D
25—2⅜-inch I. D
25—2½-inch I. D
25—2⅝-inch I. D
25—2¾-inch I. D
25—2⅞-inch I. D
25—3 -inch I. D
25—3⅛-inch I. D
25--A.L.A.M. Size
25—Metric Size

Exhaust Type Gaskets.
Fig. 6.

25—1⅛-inch C.H
25—1¼-inch C.H
25—1½-inch C.H
25—1¾-inch C.H
25—2 -inch C.H
25—2¼-inch C.H

Note—I. D. means inside diameter and C. H. refers to the type, (copper-covered diamond shape.)

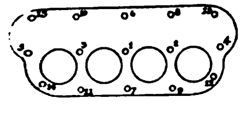
All the above is supplied on the one board. The board is given free with the order for the above lot.

Every repair shop ought to have a well assorted lot of copper or brass gaskets interlined with asbestos. A choice selection in sizes given all placed on a board to hang up in the stock room.

In addition to the type shown in illustration, other types of gaskets are supplied, such as cylinder head gaskets, etc.

Gaskets are also supplied in full sets for the Ford, Overland, Buick and other cars. Also for motorcycles.

Tightening Nuts on Cylinder Heads.



Detachable cylinder heads now are quite generally used, and it is very important in connection with them that they be kept tight against leakage at the joint with the main cylinder casting. A striking loss of power in a certain engine was puzzling until a thorough inspection revealed that some of the head bolts were **loose**, allowing some of the compression pressure to escape.

There are also many instances of careless tightening of heads and cylinder blocks which have resulted in cracking the casting. This is due to **drawing** down one bolt or series of bolts too tightly **before** equalizing the strain by tightening others in another part of casting. The object is to pull the casting down uniformly without any tendency to bend or distort it.

Diagram to the left; cylinder head has fifteen bolts, and the numbers on the diagram indicate the order in which they should be tightened. It will be seen that the center bolts are adjusted first, then the rest are tightened alternately.

To Stop Noises About Car.

When seeking to stop rattling noises about the car attend first to the fenders, then to the brakes, hood fasteners, lamps and finally to doors and springs. As a rule the fenders, doors and springs are the most troublesome source of noises on the average present-day machine.

CHART NO. 292—Gaskets. Tightening Cylinder Head Nuts.—see pages 239 and 607 for Spar Plug Gaskets.

††Oxy-Acetylene Welding.

Blow-pipe welding is a very ancient art and was first practiced by the Egyptians. The early process consisted of heating metals of a low melting point by means of a torch, using a crude fuel gas and drawing the necessary oxygen from the air.

The modern process of blow-pipe welding is somewhat similar, but it is applied successfully to the welding of *high melting point metals, as well. This was not possible until oxygen was obtainable on a commercial scale and a fuel gas giving the necessary high flame temperature could be provided in safe, convenient and purified form.

Before this process of welding was invented, when a crank case or an exhaust manifold, gear case, cylinder or other metal part was cracked or broken, it was necessary to get a new part, fully machined, from the factory. This was quite an expensive proposition. With the oxy-acetylene outfit it is possible to repair these at a very slight cost and save those parts which would otherwise be worthless. Steel, iron, aluminum, brass, copper, platinum and other metals can be perfectly united.

There are two types of oxy-acetylene outfits: the **stationary** type and the **portable** type. The parts of the stationary outfit consists of a generator which generates the acetylene gas from carbide, a tank of oxygen and a torch of special design and a special iron table with brick top.

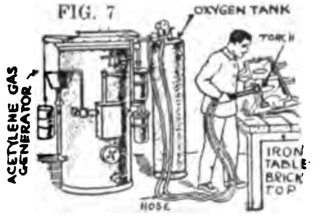


Fig. 1—The stationary oxy-acetylene outfit. Note the iron table with brick top.

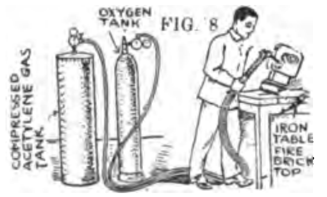


Fig. 2—**The portable** oxy-acetylene outfit.

The portable outfit consists of the same parts but instead of there being a gas generator, the acetylene gas is compressed into tanks by concerns who make a specialty of this work in all large cities. This type is the one mostly in use in small shops. The portable outfit can be put into a car and carried right to a garage for the work to be done and quite often save dismantling the engine or broken part.

Method of welding. To those who are not familiar as to just how welding operations are performed with this process, it may be said that welds are made by directing the oxy-acetylene flame on the pieces to be welded at the place where they are to be joined, until the metal is molten, and then adding additional metal of the same character, which is provided in the form of wire or sticks of suitable dimensions for the purpose.

An outfit for welding is shown in chart 293.

The oxygen is furnished to customers in portable steel cylinders into which the oxygen is compressed to 1,800 lbs. to the square inch. **To estimate the pressure readings** a gauge is supplied. Take for instance an oxygen cylinder that holds 100 cu. ft. at 120 atmospheres, or 1,800 lbs. pressure approximately, each atmosphere represents ⅚ cu. ft. With a 250 cu. ft. oxygen cylinder, each atmosphere, or 15 lbs. pressure, represents 2.08 cu. ft. of oxygen.

Acetylene is supplied to users in specially constructed steel cylinders of various capacities. The maximum charging pressure is 250 lbs. to the square inch at 70° Fahr. The cylinder contains about ten times its own volume of acetylene for each atmosphere of pressure that is on the gas. The porous substance, such as pumice stone or charcoal which is in the tank, is saturated with a liquid solvent which has the peculiar property of absorbing, or dissolving many times its own volume of acetylene at atmospheric pressure. When pressure is applied, the solvent continues to dissolve acetylene.

Cylinders are, as a rule, charged to 15 atmospheres pressure at 60° Fahr., so they contain 150 times their own volume when charged. Thus a cylinder that would hold 2 cu. ft. of water when empty will hold 300 cu. ft. of acetylene at 225 lbs. pressure, 60° Fahr.

**Prest-o-lite acetylene cylinders for welding are furnished in large size cylinders, style "WC," having approximately 100 cu. ft. capacity, and style "WK" approximately 300 cu. ft. capacity. They are made as small as 30 or 40 cu. ft. capacity.

No cylinder should be exhausted at a rate greater than ⅐th of its total capacity per hour. Where the needed amount of acetylene per hour exceeds ⅐th of the capacity of one cylinder, connect two, three or even more cylinders so the total capacity is at least seven times their hourly discharge.

It should be borne in mind that the contents are not accurately determined by pressure or gauge readings, which are affected by variations in temperature. The only accurate method is by weight, one pound of gas equaling 14½ cu. ft. Gauge pressures, however, are of great convenience in **estimating roughly** how much gas remains in the cylinder. In the case of a 100 cu. ft. cylinder each 15 lbs. of pressure represents 6⅔ cu. ft. of gas (approximately) and in a 300 cu. ft. cylinder each 15 lbs. of pressure represents 20 cu ft. (approximately)—according to temperature.

---

*See page 539, giving melting points. ††Also called autogenous welding.

**An instruction book in oxy-acetylene welding of 45 pages is published by the Prest-O-Lite Co., Indianapolis, Ind. It retails at a low price.

Application of blow pipe welding—generally known as "autogenous" welding, although the same term could apply to electric welding. Autogenous welding must not be confused with brazing or soldering. Brazing or soldering, is where a joint is made in which a different metal, having certain adhesive qualities, is used as a binder—it adheres but does not "fuse." Oxy-acetylene welding is where pieces of metal are united, or new metal added, as in the case of building up worn parts—welding iron, steel, cast iron, malleable cast iron, aluminum, brass, copper, etc.

Qualifications of an Operator.

A few weeks practice will develop skill necessary to handle ordinary work likely met with in the average shop. Very thin plate work and neat work, will of course require skill and practice.

Welding together of plates over ¼ inch thick should not be attempted on particular work, until operator has demonstrated, by first welding some sample pieces.

***The operator must have a fair knowledge** of the nature and properties of the metals being welded, the effects of expansion and contraction, the reason for the use of fluxes and filling rods, (see page 721), the proper kind of filling material, how to apply heat without burning the metal, etc.

With this knowledge and practice* the business will be very remunerative.

Parts of Welding Outfit.

The necessary parts for welding are shown in charts 293 and 293-D. We will now deal with use of same.

The welding blow pipe is shown in fig 1, chart 293: Various size tips are used for different kinds of work.

The acetylene regulator (fig. 2) is connected to the valve of the acetylene cylinder by means of the union nut (M), which must be drawn up tightly.

The oxygen regulator (fig. 3) is connected to the valve on the oxygen cylinder by means of the union nut (AA).

The Welding Flame.

Is obtained gradually, by increasing the regulating screws alternately, until correct welding flame is obtained. The correct oxygen and acetylene working pressures vary slightly for the various sizes of blow pipe tips which are used for different work. All adjustments are made at the regulators while blow pipe is alight.

Flame adjustment—it is absolutely necessary at all times that the welding flame be neutral, that is, that there be no excess of oxygen or acetylene. A correctly adjusted (neutral) flame is shown at B of fig. 4. It will be noted that the inner cone is clear, and well defined. (A) of fig. 4 shows a flame having an excess of acetylene. The inner cone is ragged in appearance. To make such a flame "neutral," the acetylene should be cut down by reducing the pressure either at the regulator or at the blow-pipe, or by increasing the oxygen supply. C of fig. 4 shows an excess of oxygen. The inner cone has a very pale violet color and is shorter than the cone in the neutral flame at B. Proper adjustment, in this case, is accomplished by reducing the oxygen pressure or increasing the acetylene pressure at the regulators or at the blow-pipe.

The temperature of the oxy-acetylene flame is 6,300° Fahr.

The regulation of the welding flame really means the regulation of the white inner cone. This cone should always be as large as possible, provided its outline is sharp and distinct. A long, clear inner cone should always be sought. The gases should be readjusted several times, if necessary, until the desired result is obtained.

When the blow-pipe is first lighted, it is cold. Radiated heat from the molten metal will gradually warm it. This is apt to affect the welding flame slightly. It usually will be found necessary to make readjustment of the gas pressures by means of the oxygen and acetylene needle valve on the blow-pipe after the blow-pipe has been at work for a few minutes.

Method and Material for Welding.

***Preheating and re-heating** is sometimes necessary—in order to bring the metal to a uniform heat to insure uniform contraction while cooling. Figs. 17 and 19, show devices for this purpose (chart 293). (See also fig. 5, page 726.)

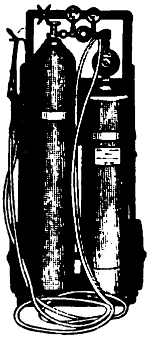
Filling rods are used to fill in gaps or cracks. Rods or wires are used of various lengths.

Fluxes—some metals do not flow together rapidly when heated (due to oxidation), therefore a suitable flux, in the form of powder is used. It is sprinkled in the weld by dipping the heated filling rod, from time to time into the flux.

The size of blow pipe tip is decided upon before welding. For instance, cast iron requires a larger flame than steel.

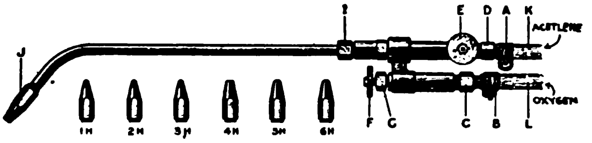
---

*Can be learned from this instruction and the booklet Supplied by Prest-O-Lite Co.



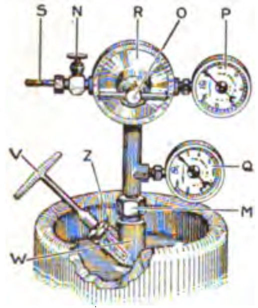
The Standard Prest-O-Lite Type H Welding Outfit.

1—cylinder of Prest-O-Lite dissolved Acetylene.
1—cylinder of compressed Oxygen.
1—welding blow-pipe with seven interchangeable welding tips, Nos. 1, 2, 3, 4, 5, 6 and 7. (Fig. 1.)
1—automatic constant pressure acetylene regulator, fitted with inlet and outlet pressure gauges. (Fig. 2.)
1—automatic constant pressure oxygen regulator fitted with inlet and outlet pressure gauges. (Fig. 3.)
2—suitable lengths of rubber hose.
1—set of four hose clamps.
1—box end wrench for needle on Prest-O-Lite dissolved acetylene cylinder valve (T socket).
1—wrench for attaching oxygen regulator.
1—stuffing nut wrench for Prest-O-Lite dissolved acetylene cylinder and for attaching acetylene regulator.
1—box end wrench for welding blow-pipe.
1—box wrench for welding tips.
1—pair special colored lens goggles.



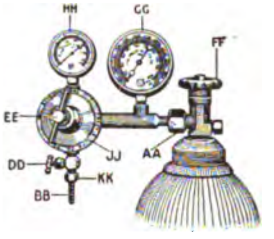
PREST-O-LITE WELDING BLOWPIPE

Fig. 1. *Prest-O-Lite equal pressure welding blow-pipe. (A) Clamp for holding acetylene hose on nipple. (B) Clamp for holding oxygen hose on nipple. (C) Union nut on oxygen hose nipple. (D) Union nut on acetylene hose nipple. (E) Needle valve for controlling acetylene supply. (F) Needle valve for controlling oxygen supply. (G) Stuffing nut on oxygen needle valve. (I) Union nut for disengaging or changing angle of barrel of blow-pipe. (J) Interchangeable welding tip, size 7H—1H, 2H, 3H, 4H, 5H and 6H are extra interchangeable welding tips.*



ACETYLENE REGULATOR ASSEMBLY

Fig. 2. *Prest-O-Lite automatic constant pressure acetylene regulator. (M) Union nut securing regulator on acetylene cylinder valve. (N) Acetylene regulator outlet needle valve. (O) Acetylene pressure regulator screw. (P) Low or working pressure gauge. (Q) High or cylinder pressure gauge. (R) Acetylene reducing valve. (S) Acetylene hose nipple. (V) Wrench on acetylene cylinder valve. (W) Acetylene cylinder valve. (Z) Gland nut on acetylene cylinder valve.*



OXYGEN WELDING REGULATOR ASSEMBLY

Fig. 3. *Prest-O-Lite automatic constant pressure oxygen regulator. (AA) Union nut securing regulator on oxygen cylinder valve. (BB) Nipple for hose to blow-pipe. (DD) Oxygen regulator outlet valve. (EE) Oxygen pressure regulating screw. (FF) Main valve on oxygen cylinder. (GG) High or cylinder pressure gauge. (HH) Low or working pressure gauge. (JJ) Oxygen reducing valve. (KK) Union nut on oxygen hose nipple.*

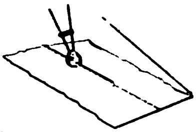


Fig. 11. *Method of holding flanged thin sheets in position for welding.*

Fig. 12. *Clamp with locking ring.*

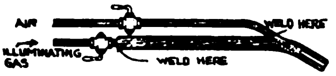


Fig. 17. *Construction of air-illuminating gas pre-heating torch. Over all length, approximately 2 feet.*

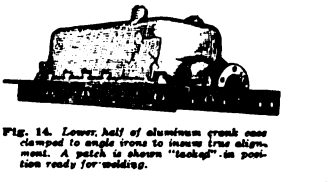


Fig. 14. *Lower half of aluminum crank case clamped to angle irons to insure true alignment. A patch is shown "tacked" in position ready for welding.*

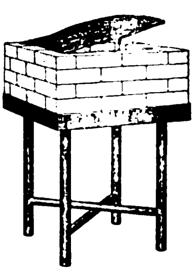


Fig. 19. *Fire brick furnace mounted on small welding table.*

In all welding operations, the parts to be welded should be set in proper alignment before the flame is applied. The work is sometimes found to be out of alignment and the part rendered useless otherwise.

It is always advisable to have on hand a good supply of different size clamps, "V" blocks and mandrels. These are always useful in setting up various jobs. see figs. 13, 14, 15 and 16.

Expansion and contraction—In every case of welding, internal strains are inevitably set up due to expansion when heating and contraction when cooling. When parts being welded form part of a structure and are not free to move during the welding process, the strains produced may cause the metal to crack. This is especially true of cast iron.

If cooling after welding is too rapid or is irregular, a crack is liable to occur. Therefore it is advisable to heat parts before welding (termed pre-heating) and then to heat after welding (termed re-heating.)

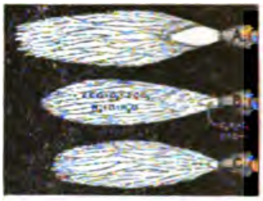


Fig. 4. *The oxy-acetylene flame. A shows a welding flame with an excess of acetylene. (B) shows a correct natural welding flame. (C) shows a welding flame with an excess of oxygen.*

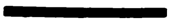


Fig. 5. *Example of butt joint before welding employed on thin sheet metal up to 1/8 inch in thickness where beveling is unnecessary.*

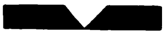


Fig. 6. *Example of bevel employed on metal less than 5/8 inch or 3/4 inch in thickness and over 1/8 inch in thickness.*

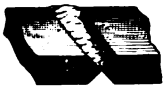


Fig. 7. *Example of beveling and welding of sections over 3/4 inch in thickness. Parts are bevelled and welded on both sides as shown.*

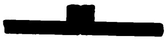


Fig. 8. *Example of flange made on thin sheets, before welding.*

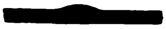


Fig. 9. *Shows appearance of a weld made on thin sheets, flanged before welding.*

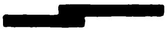


Fig. 10. *Examples of a lap joint, before welding*

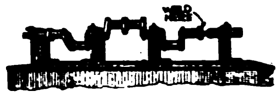


Fig. 13. *Example of six-throw crank shaft lined up on "V" blocks and clamped on face plate for welding. The broken sections are shown bevelled to a chisel edge.*

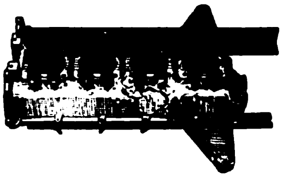


Fig. 15. *Upper half of aluminum crank case bolted to angle irons to insure true alignment while patching.*

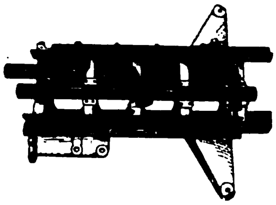


Fig. 16. *Under side of upper half of aluminum crank case shown in Fig. 15. Note mandrels clamped in crank and cam-shaft bearings.*

HART NO. 293—Oxy-Acetylene Welding. (from Prest-O-Lite Instruction Book.)
se also page 696 and 472 for illuminating gas torches.

Welding a Cylinder—Importance of Preheating.

Fig. 5, page 726 shows a small furnace for automobile cylinders. After a layer of firebrick has been placed on the table, the cylinder is supported on several bricks, and the walls of the furnace built up around it. Half bricks are used for the second layer from the bottom, so that openings are left for the air supply.

The fuel used should be the best grade of hardwood charcoal obtainable. This burns freely, without smoke or odor, requires no forced draft, and does not injure finished surfaces. It is only necessary to pack it around the piece to be heated, to light it, and let it burn at will. When in use the top of the furnace should be covered with a sheet metal plate. Vent holes should be closed when cooling. (cool slowly.)

Iron and Steels.

Under this heading are included commercial wrought iron and mild or "low carbon" steel.

Practically all of the so-called **"wrought" iron** on the market today is in reality a **mild steel.** For this reason wrought iron and mild steel metals are discussed as one.

"Low carbon" or mild steel is quite ductile and malleable, but has a lower tensile strength and lower elastic limit than the "high carbon" or hard steels. No close distinction can be made between high and low carbon steels, but in general anything below 25 point carbon (0.25 per cent) may be designated as mild steel, while those containing more than this amount are either half hard or hard.

Most of the steels that the operator will be called upon to weld are mild. There are various special or alloy steels such as vanadium, nickel, chrome, manganese, etc., which will be taken up separately.

Preparation of parts—Mild steel parts are prepared in the manner described in the general instructions. Several methods of preparing various parts to be welded are shown in the accompanying illustrations. see chart 293A, figs. 24 to 41 inclusive.

High carbon or hard steel—weld as per instructions on mild steel or wrought iron, and use a larger blow-pipe tip. For filling use drill rod—a hard steel—this can be tempered, ordinary mild steel cannot. Use cast iron flux. Execute weld rapidly. A slight excess of acetylene may be advantageous.

Cast steel—weld similar to instruction on cast iron. Cast bars of same material or vanadium steel or Norway iron will answer for fillers.

Special steels—such as manganese steel (low carbon). As filler use same material or Norway iron.

Nickel steel (low carbon) same as mild steel, but use nickel steel filling rod.

Vanadium steel (low carbon) probably used most of the various steel alloys. Weld as mild steel—use vanadium steel filler.

Chrome steel—weld as mild steel—use chrome steel filler. Many chrome steels are in the high carbon class and general remarks on "special steels" apply.

Cast Iron.

Is more difficult to weld. Carbon exists in cast iron in different states. In what is called white iron, which is very hard, the carbon is combined with or dissolved in the iron. In the grey iron, which is soft and easy to work, most of the carbon is in a free state in the form of graphite. Since it is generally necessary to machine or file a weld in cast iron, it is indispensable that the line of the weld be constituted of soft grey iron. Thus, in welding cast iron, always remember that too rapid cooling brings about a combination of the carbon and iron, forming hard, brittle white iron; while slow cooling or reheating after the weld is completed keeps the carbon in a free state, resulting in a softer, more workable material.

Preparation of parts—castings, before welding, should be very carefully freed from grease and rust. Cracks in metal over 3/16 inch thick must always be beveled before welding. When beveling cast iron it is not necessary that the groove penetrate through the entire thickness of the metal. It will be found best to leave about ⅛ inch of the thickness unbeveled as shown in fig. 38, chart 293A. When the metal is over 1 inch in thickness, and it is possible to weld from both sides, it will be well to bevel as shown in fig. 39. A diamond point or cape chisel may be used for beveling cast iron. Remember that careful lining up and clamping is very necessary when broken flanges or lugs are to be welded.

A larger blow-pipe tip is used. To overcome expansion and contraction—pre-heat. While welding is in progress and after its completion it is advisable to apply a blow torch or light a fire under some part of casting away from the weld.

Filling material—use cast iron filling rod containing a percentage of silicon. The percentage must not be too great or weld will be soft. **Flux**—cast iron flux is necessary.

Malleable cast iron is probably more difficult to weld and treat than any other metal. Castings to be made malleable are made of white iron. Use same process as cast iron with **white** iron filler.

Cast Aluminum.

Has a low melting point (1,200° Fahr., see page 539 for other melting points). A large welding flame is used. Aluminum is not generally used in pure form. Alloys of aluminum and copper or zinc are generally used. Alloys of aluminum and copper are

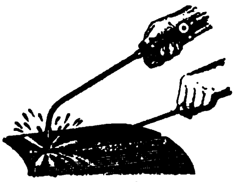


Fig. 21. *Correct method of holding the blow-pipe with relation to the line of weld.*

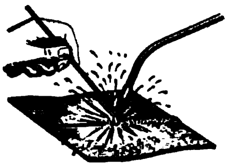


Fig. 22. *Incorrect method of applying filling material. The blow-pipe is also held at the wrong angle with relation to line of weld.*

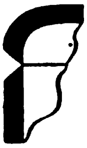


Fig. 24. *Location of joint when welding convex end to steel cylinder.*

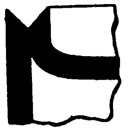


Fig. 25. *Example of welding concave head in steel cylinder. Note: Both head and shell are bevelled.*

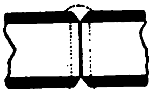


Fig. 26. *Pipes bevelled before butt welding.*

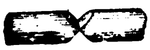


Fig. 27. [illegible] *method of preparin, (bevelled to chisel for welding.* *

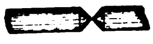


Fig. 28. *Incorrect method of preparing shaft (pointed) for welding.*

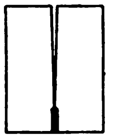


Fig. 29. *Sheets spreading apart away from point of weld.*

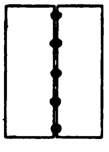


Fig. 30. *Sheets "tacked" before welding to prevent spreading.*

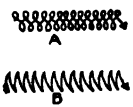


Fig. 20. *Two correct movements to give the welding flame. (A) "figure eight" movement best suited to ordinary work. (B) zigzag movement which some operators prefer.*

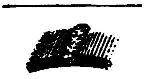


Fig. 23. *Metal is slightly built up over bevelled joint.*

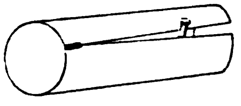


Fig. 31. *Wedge inserted in split tube ahead of weld to prevent overlapping.*

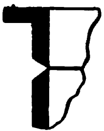


Fig. 32. *Preparation of angle iron and tube of same thickness before welding.*

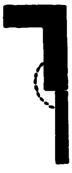


Fig. 33. *Dotted line shows how filling material must be built up when welding angle to thinner section plate.*

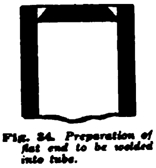


Fig. 34. *Preparation of flat end to be welded into tube.*

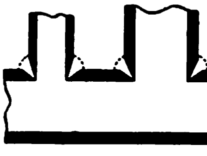


Fig. 35. *Shows preparation of pipes before welding to form branches.*

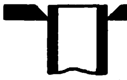


Fig. 36. *Preparation of flange to be welded to thinner section plate.*

Fig. 24 shows a section of one side of a steel cylinder and a convex head which is to be welded on. The weld should be made in the straight portion of the cylinder as shown, and not directly at the bend.

Fig. 25 shows the method of accomplishing the same result in the case of a concave end. If the parts are beveled as shown, the joint will be a strong one.

Fig. 26 shows correct method of welding pipe. The pipe, where possible, should be rolled away from the operator in such a way that the portion being welded will be on top. "Tacking" at several points is necessary before the actual welding is started. However, if rolling is impossible, the pipe may remain stationary and the operator can weld entirely around it without difficulty after some practice, although this method is bound to be somewhat slower.

Fig. 27 shows the proper method of preparing a shaft for welding. Note that this is beveled to a chisel edge and not pointed.

Fig. 28. If the shaft is pointed, the molten metal will fall upon the cold part of the shaft and adhesion will result, which means that the new metal is merely "plastered" on at certain points and is not "fused."

Fig. 29—When butt welding two lengths of plate, or when welding the longitudinal seam of a cylinder, it is advisable to "tack" along the line of weld before commencing on the finished weld. This will prevent the over-lapping of the sheets at the end farthest away from the point of welding. When starting to weld two lengths of sheet at one end, which have previously been placed in proper alignment, it will be found that they tend to spread apart as shown in illustration. As the welding progresses, this spreading movement of the sheets ceases and later they come together again with a tendency to overlap.

Fig. 30—"Tacking" holds the sheets in true alignment and prevents this overlapping.

Fig. 31—Another method of preventing over-lapping of the plates, in the case of cylinders, is to insert a wedge a short distance ahead of the weld, moving the wedge as the weld progresses.

In some cases when welding a longitudinal seam, it will be found advantageous to start to weld in the middle of the seam and work first toward one end and then toward the other.

Fig. 32—When welding angle iron rings to cylinders where the thicknesses are the same, both edges should be set up as shown.

Fig. 33—When the angle to be welded to the plate is thicker than the plate, apply the flame more on the angle than on the plate. This will tend to bring the parts to the fusion point at the same time. Metal must be added as shown by the dotted line.

Fig. 34—When welding a flat end into a tube, prepare the end as shown, making a driving fit.

Fig. 35—To weld a branch into a pipe, prepare the work as shown, adding metal as indicated by the dotted lines.

Fig. 36—The welding of flat flanges to tubes is an operation that requires care, as the flange is usually considerably thicker than the tube and has to stand a good deal of strain. The flange and tube are best prepared as shown. The welding flame should play more on the flange than on the tube.

Fig. 37—When repairing cracks in plates, always see that the crack is bevelled through its entire thickness. The plate being welded should be free to move. It is impossible to provide for this, instead of attempting to repair the crack, use a patch. A patch piece should always be slightly bellied and have edges bevelled as indicated in illustration.

Selection of blow-pipe tip—The size of tip to use for welding iron and steel depends upon the thickness of the metal. Do not forget that the flame should be neutral at all times.

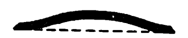


Fig. 37. *Patch plate bellied and with edges bevelled before welding.*

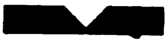


Fig. 38. *Bevelling cast iron. Note bevel does not penetrate entire thickness to be welded.*

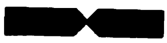


Fig. 39. *Bevelling from both sides in thick section of cast iron. Note: Points of bevels do not meet*

Fig. 40. *Fracture in the middle of a long bar to be welded. No precautions to overcome expansion and contraction strains are necessary, as the parts are free to move.*

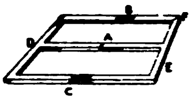


Fig. 41. *Fracture in cross member (A) of frame. The broken bar will contract on cooling, causing a strain on the end members (D and E). Risk of fracture may be avoided by heating the side members (B and C), or by cutting at the corner (F). The cut (F) may be welded up without risk of fracture after the break (A) is welded and cooled.*

CHART NO. 298-A—Oxy-Acetylene Welding—Continued.

*Fig. 27 should read: "Correct method of preparing shaft (bevelled to chisel edge) for welding."

easier to weld—less tendency to crack. Parts over ¼ inch thick must be beveled as in case of cast iron.

In order to prevent collapse during the welding and preheating operations, it is good practice to place a sheet of paper on the inside of the casting next to the crack to be welded. Back this paper with damp fire clay and pack up with asbestos fibre until a firm support is obtained. The paper prevents the fire clay from getting into the weld. With this light backing, or mould, the castings can be welded easily. The mould should be large enough to cover sufficient area around the crack so that the heated aluminum in the vicinity of the weld will not break down. Whenever a weld is to be made close to a bearing, it is necessary to remove the babbit (which would melt) and then clamp mandrels (fig. 16, chart 293) in the bearings to keep them in alignment.

Preheating should not be done except in cases where there is a projecting lug or flange. Preheating must be done carefully and slowly. A blow torch is generally used, but must not be left on one part too long. When pre-heating, test with a stick of half and half solder—if it melts on touching casting it shows sufficient heating.

Filling—Alloy rods or pure aluminum rods can be employed—same thickness as metal to be welded.

Flux—opinions differ. Use aluminum flux if any.

Copper, Bronze and Lead.

Copper radiates heat very rapidly and is also a good conductor of heat. Pre-heating and continued heating is therefore necessary. Prepared similar to steel and iron. Cover as much as possible with asbestos. Should be left free to allow for contraction when cooling. **Filling**; phosphor copper, **Flux** must be used, same as welding brass.

Brass—Pre-heating not necessary. Use special flux for brass and bronze. Filler; brass spelter. Tobin bronze with brass flux may be used where great strength is desired. Weld should be made rapidly, but white cone of flame must not touch metal.

Lead—can readily be welded but is known as "lead burning." (see page 471).

Welding Thin Castings.

The inexperienced operator will find it a big help to build a form of fire clay as a support for the broken sections while repairing thin castings. This holds the parts true and also assists in the control of the molten metal.

Whenever it is necessary to weld in a patch, a new piece of the same metal should be cut to the proper size and shape, the edges of both parts bevelled, and the patch held in place temporarily by "tacking," that is, welding at several spots some distance apart along the line to be welded. To hold a large patch in position while being "tacked," it may sometimes be necessary to drill a small hole in the center of the patch into which a length of rod can be inserted, and by which the patch may be handled. This hole may afterwards be plugged and welded up. Small patches, to be placed in difficult positions, may be conveniently handled by simply welding a filling rod to the center of the patch. This may later be melted off.

Sundry Uses.

Tool hardening—The welding flame will be found useful as a source of heat for the heat treatment of small tools.

Gear tooth hardening—Gear teeth may be hardened by playing the welding flame along the face of a tooth and then allowing the heat to be conducted away by the body of the gear. The intense heat of the flame permits of a single tooth being heated very rapidly, before much heat is conducted to the rest of the gear. As soon as the flame is removed the heat in the treated tooth is conducted away to the body of the gear This causes hardening of the tooth. This operation is repeated until the desired depth of hardening is reached.

Teeth may be hardened by this method to a depth of about 3/32 inch. The rapidity with which the treated tooth may be chilled will be increased if the gear is partly immersed in water while the treatment is performed.

Burning battery terminals or connections—see page 471.

*Approximate Prices to Charge for Welding Broken Parts by the Oxy-Acetylene Process.

Cylinders, Water Jackets Fractures.

Double	$ 8.00 to $15.00
Single	4.00 to 8.00
Block of four or six	10.00 to 15.00
Lug or ears each	$3.50 two or more 3.00

Aluminum Crank Case and Lower Cases.

It is very difficult to determine an exact price on this line of work without a thorough examination of the fractures, but as a general rule the average cost of welding is as follows:

Top cases	$6.00 to $25.00
Lower cases	6.00 to 12.00

Manifolds Aluminum.

1 lug or ear....$1.50 Two or more $1.00 each.

Cast Iron.

1 lug or ear....$1.25 Two or more $0.75 each.

*Not standard, merely a suggestion.

Crank Shafts.

1 throw crank	$ 6.00 to $ 8.00
2 throw crank	8.00 to 10.00
4 throw crank	10.00 to 14.00
6 throw crank	12.00 to 16.00

Body Frames.

Two inches	$ 7.00
Three inches	8.00
Four inches	10.00
Five inches	12.00
Six inches	15.00
Eight inches	17.00

Rear Axle Housings.

Prices vary according to size and fractures, but they average from $8.00 to $18.00.

Lamp brackets	$0.50 to $1.50
Levers	.75 to 2.00

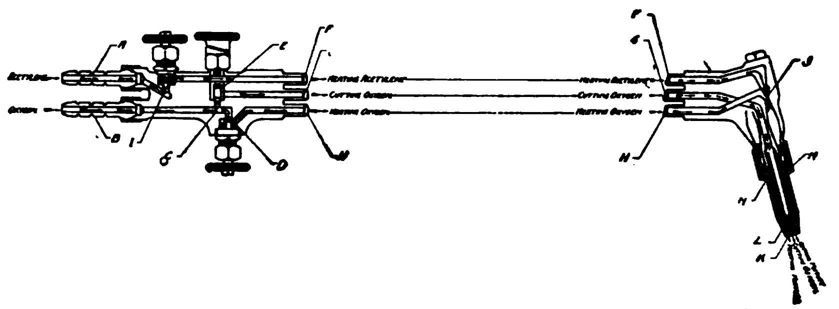


Fig. 45. Diagram illustrating the principle of the oxy-acetylene cutting blow-pipe.

Oxy-Acetylene Cutting.

The cutting blow-pipe is commonly used for cutting through various thicknesses of wrought iron and steel up to 14 inches. (Wrought iron and steel are the only metals that can be cut by this process.) As an adjunct to a welding equipment, it is used for bevelling and for cutting out patches and holes.

The process is based on the fact that a jet of oxygen directed upon a previously heated spot of iron or steel, causes it to ignite, with the result that the metal, acting as its own fuel, burns away rapidly in the form of iron oxide. A special blow-pipe is provided for this work. (Fig. 45.)

The oxygen cutting blow-pipe cannot be used for welding any more than can the welding blow-pipe be used for cutting.

The same source of gas supply is used as for welding. The same acetylene regulator is used, but, if work over 8 inches thick is to be cut, a **special oxygen regulator** must be employed. This is exactly the same in appearance as the oxygen regulator for welding but it is fitted with a stronger spring and a higher reading outlet or "working" pressure gauge.

The special oxygen regulator as used for cutting thick work should not be used for welding, as the regulation is not delicate enough to maintain a strictly neutral flame, especially when the smaller tips are in use. The oxygen regulator for welding, however, can be used for cutting on work up to 1½ inch in thickness.

The oxygen cutting regulator is connected to the oxygen bottle in the same manner as the welding regulator. The cutting blow-pipe is connected to the gas supply through the regulators in exactly the same way as the welding blow-pipe.

There are two kinds of oxy-acetylene cutting blow-pipes, known as the central and following jet types. The central jet type has a number of oxy-acetylene heating flames surrounding a central hole through which oxygen only passes. The following jet type consists of one oxy-acetylene heating jet and one oxygen jet. The holes for these jets are usually drilled in the same tip, but sometimes have separate tips which are set close together.

Fig. 45 illustrates the principles of construction and operation of an oxy-acetylene cutting blow-pipe of the central jet type. The oxygen and acetylene supplies are connected up through the regulators and rubber hose to the hose nipples on the blow-pipe.

The outlet valves on both regulators and also all valves in the blow-pipe are closed. The gas is then turned on at the cylinders as in welding, and the regulators adjusted until the outlet or working pressure gauges show the working pressures specified on the instructions issued with the cutting blow-pipe by its manufacturer. The acetylene valve in the blow-pipe is then slightly opened and the blow-pipe lighted, the oxygen for the heating flame is then turned in at valve D of fig. 45. This permits oxygen to mix with the acetylene at J. The flow of the mixture of the gases is indicated by arrows. Valves D and I are adjusted until a neutral heating flame is produced. The cutting oxygen is then turned on at E.

The line of flow of the cutting oxygen is shown by arrows. The nipple or inner tip through which it discharges is interchangeable and manufacturers indicate in their instructions the number or size of tip to be used on different thicknesses of metal.

Watch the working pressure gauge on the oxygen regulator and see if it reads the right pressure for the metal to be cut as originally set, if not adjust regulator and when this is done readjust the heating flame if necessary. Do this as quickly as possible to avoid waste of oxygen. Now shut off the cutting oxygen at E and the blow-pipe is ready for work.

When the metal to be cut is sufficiently heated at the point where the cutting is to start, the cutting oxygen is turned on. When the cutting operation is once under way, the heating and cutting proceed together. The cutting operation is very simple and can be mastered in a few hours.

Cutting may be made to follow any desired line. When special forms and shapes have to be cut, it is advisable to make a special mechanical contrivance with which to steady and guide the blow-pipe and thus insure a clean cut. Hold the blow-pipe tip about ¼ inch away from the surface of the metal to be cut.

A cut should start from the edge of the metal whenever possible. When it is desired to cut a piece out of the center of a plate, start inside the circumference of the piece to be cut (fig. 46). On thick plates where the cut cannot be started from the edge, it may be necessary to drill a hole to get a quick start.

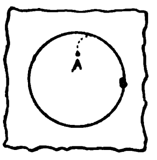


Fig. 46. *Shows point of start (A) when cutting circular hole in plate.*

Certain precautions are necessary before the operator starts to work on a piece of metal. A bucket of water should be near at hand for cooling the cutting tip when necessary. Both oxygen and acetylene should be shut off at the blow-pipe to extinguish the flame before dipping the tip of the blow-pipe into the water. To expel any steam formed inside the tip, turn on the oxygen valves at the blow-pipe and allow oxygen to flow for a moment before turning on the acetylene and lighting.

These and many other parts from an auto too numerous to mention can be welded successfully.

All up to date welding and cutting shops have the latest modern equipment installed to take care of all classes of work such as pre-heating cylinders, cases, etc.

The cutting process of this art consists of the cutting and wrecking of all kinds of "I beams," "channel iron," "girders," cutting of boilers," "tanks," "cutting and opening of safes," "steel pilings," etc.

Pure oxygen used in the process of removing carbon from cylinders is one of the latest and most advantageous features to the automobile owner.

The Cost of Welding.

Thickness of Metal	Size of tip to be used	Acetylene		Oxygen		Total cost of gas per hour	Approximate capacity per hour of welded seam
		Consumption per hour	Cost of gas per hour	Consumption per hour	Cost of gas per hour		
3/16" to ¼"	No. 3	15 cu. feet	$0.30	17 cu. feet	$0.34	$0.64	15 to 20 lineal feet
⅜" to ½"	No. 5	43 cu. feet	.86	47 cu. feet	.94	1.80	7 to 12 lineal feet

Note:—In welding metals of from 3/16" to ¼" in thickness, the average approximate capacity, expressed in terms of lineal feet of welded seam, would be from 15 to 20 feet per hour, being a cost for gas of from 3 to 4 cents per lineal foot. For metals ⅜" to ½" in thickness, the approximate capacity would be from 7 to 12 lineal feet per hour, being a cost for gas of from 15 to 25 cents per lineal foot.

Under continuous use with the No. 3 tip a cylinder containing 100 cubic feet of acetylene will run about 6⅓ hours, while the same quantity of oxygen, would run about 6 hours.

With the No. 5 tip, a cylinder containing 100 cubic feet of acetylene would run about 2⅛ hours, while the same quantity of oxygen would run about 2 hours.

The Cost of Cutting.

Thickness of Metal	Acetylene		Oxygen		Time required per foot of cutting length	Total cost of gas per cutting foot
	Consumption per lineal foot	Cost per lineal foot	Consumption per lineal foot	Cost per lineal foot		
¼"	.13 cu. feet	$0.003	.50 cu. feet	$0.01	1 minute	1¼ to 1⅜ cents
⅜"	.18 cu. feet	0.0036	.90 cu. feet	0.018	1¼ minutes	2⅛ to 2⅜ cents

Note:—In continuous cutting through metal ¼" thick, the cost for gas would be about $0.02 per running foot and the time about one minute.

For metal ⅜" thick, the cost of gas per running foot would be about $0.03 per foot and the time about 1¼ minutes.

When cutting ¼" metal, a cylinder containing 100 cubic feet of acetylene would run about 12 hours, while the same quantity of oxygen would run about 3⅛ hours.

For ⅜" metal, a tank containing 100 cubic feet of acetylene would run about 11½ hours, while the same quantity of oxygen would run about 2⅛ hours.

It will be noted that in the process of cutting the extra quantity of oxygen required is due to the cutting jet of pure oxygen which is used in addition to that mixed with the acetylene.

Tanks containing 200 cubic feet of gas would run twice as long as the 100-foot tanks.

The above estimates are based on acetylene and oxygen gas costing $2.00 per 100 cubic feet. Cost of labor should be added to the total cost of gas.

Where to Obtain Gas Tanks for Welding.

Oxygen and Acetylene Gas for use with Imperial Welding and Cutting Outfits.

Oxygen for welding and cutting can be obtained from the Linde Air Products Co. of Chicago, and New York, who have twelve plants and twenty-five warehouses in various parts of the country. They furnish oxygen in tanks containing 100 and 200 cubic feet respectively, with free use of tanks.

Acetylene Gas for Welding and Cutting:

There are several manufacturers of acetylene gas, as mentioned below: The Prest-O-Lite Company of Indianapolis, Ind., who have branches in nearly all the large cities of the United States.

The Searchlight Company of Chicago. This company has branches in many of the large cities of the United States.

The Commercial Acetylene Ry. Light & Signal Company of New York have numerous branches. We are advised they supply acetylene for welding and cutting. The tanks contain 120 and 225 cubic feet.

Approximate Shipping Weights are as Follows:

Linde	100 cu. ft.	122 lbs.
Linde	200 cu. ft.	150 lbs.
Prest-O-Lite	100 cu. ft.	85 lbs.
Prest-O-Lite	300 cu. ft.	220 lbs.
Searchlight	100 cu. ft.	75 lbs.
Searchlight	225 cu. ft.	180 lbs.
Commercial	120 cu. ft.	120 lbs.
Commercial	225 cu. ft.	180 lbs.

Weight of acetylene is approximately 14½ cu. ft. to a pound.

The price of oxygen and acetylene varies somewhat, depending on location. Prices in the extreme West and South being somewhat more than in the East. The prices in the East for both oxygen and acetylene are approximately $2.00 per hundred cubic feet at the filling station or warehouse.

You can obtain full information regarding oxygen and acetylene by corresponding with the above companies at the branch nearest to you.

To provide a constant supply of gas for your shop, you can no doubt arrange to get the use of from three to six cylinders or more, according to requirements which would eliminate possibility of running out of gas by having extra cylinders on hand for use while getting empties recharged.

Your automobile supply house with whom you are trading may be able to give you additional information on this subject.

Oxy-Hydrogen.

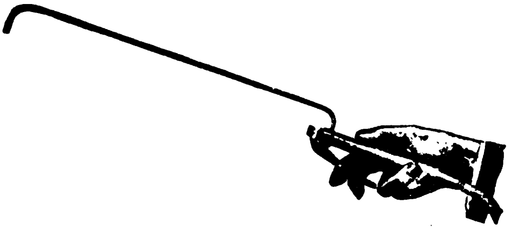
An important feature to the Imperial welding and cutting equipment is its adaptability for use with oxy-hydrogen as well as oxy-acetylene. When it is desired to equip for both oxy-hydrogen and oxy-acetylene, the only change necessary is the addition of one hydrogen regulator and a set of hydrogen tips.

Tips for welding as well as cutting with hydrogen can be furnished. The tip is marked with the pressure of gases required.

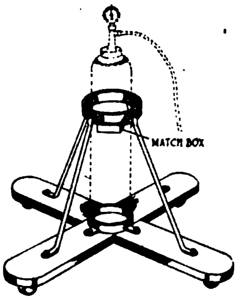
Where a supply of hydrogen is available at reasonable prices, it is recommended in connection with oxygen for cutting of wrought iron and steel of any thickness. The cut will be found smoother and the operation more economical than by the use of acetylene for the preheating flame.

For welding in general repair work, such as gears and castings, aluminum crank cases and other alloyed metals, the use of the oxy-hydrogen flame is recommended. For welding thin sheet steel, from 16 gauge up, the oxy-hydrogen flame is found very effective. Its temperature being about 4,000 degrees F., the metal is not burned so easily and as hydrogen contains no carbon, the weld is softer and very uniform. Cast iron may be welded with oxy-hydrogen very successfully up to ⅜" in thickness.

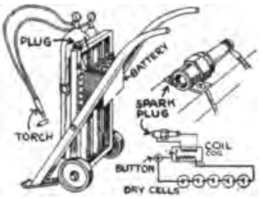
For welding steel of more than ¼ inch in thickness, the oxy-acetylene flame should be used under all circumstances.



The Prest-O-Lite carbon torch which can be used with the regular welding (oxygen) tank is for removal of carbon from cylinder, as explained in chart 249-A. (see also page 625). The average cost of removal of carbon is 10c per cylinder. The oxygen pressure is obtained through a reducing valve, with which oxygen tank should be equipped before carbon burning is attempted. The necessary pressure is about 15 lbs. The average price charged for removing carbon from an engine is 50c per cylinder.



A durable and portable stand for carrying the oxygen tank of a carbon burning outfit is here illustrated. The base is wood, X-shaped and bolted together. Four steel uprights hold a ring in which the tank is held, and a tin match box on the side of the ring holds the necessary matches. The tank is prevented from slipping by another ring bolted to the base, and the base is mounted on casters.



A means of electrically lighting the welding torch is shown above. A box, holding several dry cells, and a spark coil, is mounted at the rear of the welding truck, and is connected to a spark plug attached to the top of the frame. The plug is thrown into operation by a push button connected into the battery circuit. This system of lighting is particularly adapted to short welding jobs.

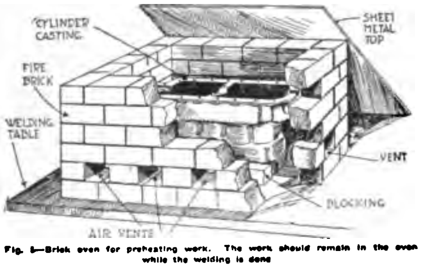


Fig. 5—Brick oven for preheating work. The work should remain in the oven while the welding is done

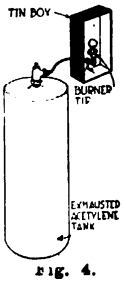


Fig. 4.

Fig. 5—Pre-heating furnace for cylinders. This subject is explained on page 721. When welding is finished the cylinder should be covered with fresh layer of charcoal, heated—then allow to grow cold slowly. Many shops will not take in water jacketed cylinder work—due to difficulty in the job holding. Cause generally due to improper pre-heating.

Small jobs may be pre-heated with welding torch, blow torch or forge.

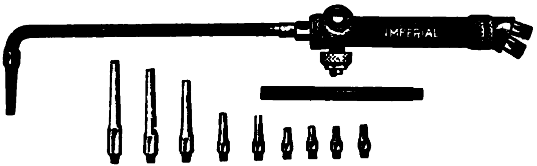
Fig. 4—A welding pilot light: When the gas in the welding tank becomes too low for welding purposes there is still sufficient gas for supplying a pilot light as per fig. 4. The light comprises a small gas tip arranged in a tin box as shown.

Pointers on Welding.

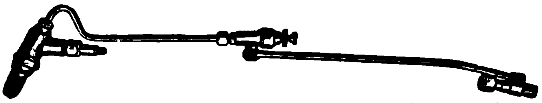
1. Always shut off the gas at the cylinder valves when the work is finished.
2. Never leave pressure in the regulators when not in use. The pressure gauges will indicate this.
3. Never clean out a blow-pipe tip with a sharp, hard tool.
4. Before attaching rubber hose to blow-pipe or regulator, make sure that the inside of the hose is free from dust or powder (used as a preservative), which is apt to choke the blow-pipe inlets.
5. Always use the wrenches provided for the cylinder valves.
6. Do not use the top of the acetylene cylinder as a receptacle for tools.
7. Do not under any circumstances use oil or grease on oxygen cylinder valves or regulators.
8. Always see that the hose is clamped securely to the blow-pipe and regulators before using.
9. Always wear the goggles provided when working with the lighted blow-pipe.
10. In case the flame goes out at the tip or burns back of the tip, shut off first oxygen, then acetylene at the blow-pipe.
11. When working in a confined place always have a helper nearby to shut off the gas supplies at the cylinders in case of necessity.
12. Always see that you have enough gases on hand to complete a job.
13. Always turn on the cylinder valves slowly.
14. Always leave wrench on acetylene cylinder valve when in use.
15. Always have a bucket of water handy while welding or cutting for cooling the blow-pipe tips when necessary.
16. In disconnecting an empty acetylene cylinder from the welding outfit, remember to CLOSE THE CYLINDER VALVE tightly. Remember that the acetone in an empty cylinder is inflammable, and that, should the temperature in the room increase, an open valve would permit vapor to escape, as well as any slight quantity of gas which might yet remain in the cylinder. For these same reasons, the railroads require that valves be closed before shipping. The simplest and best way is to CLOSE THE VALVE when disconnecting the cylinder from the welding outfit.
17. Return empty gas cylinder immediately to insure prompt exchange service. Prepay the freight when shipping empty cylinders. Remove "inflammable" red labels from acetylene cylinders before shipping empty and ship as "empty returned gas cylinder" to get lowest freight rate.
18. Never open acetylene cylinder valve more than one full turn of the spindle.

CHART NO. 293-C—Torch for Carbon Removal. Tank Stand. Torch Igniter. Pointers on Welding.

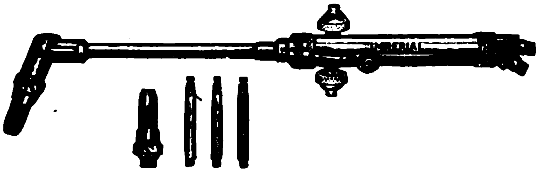
*See advertisement of **Continental Welding Table** in back of book.



Type B welding torch as furnished with Imperial outfits Nos. 1, 4 and 5....................$25.00



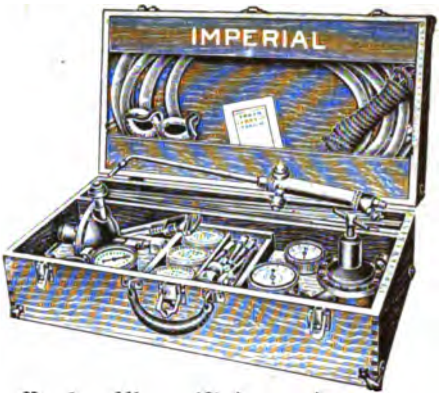
Type DB cutting attachment for use with type B welding torch. Makes it possible to weld or cut with one torch, as furnished with Imperial outfit No. 4 ....$20.00



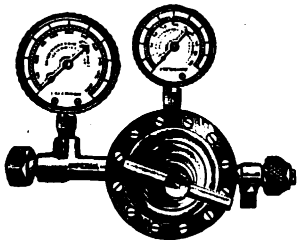
Type B cutting torch as furnished with Imperial outfits Nos. 3 and 5......................$45.00

Imperial portable truck.

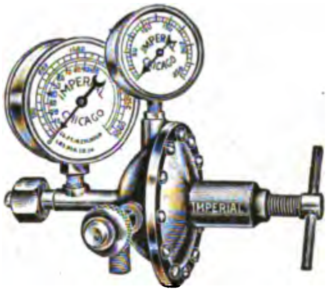
No. 6 Oxygen decarbonizing outfit with type (G) torch and hose—see page 624.



No. 1 welding outfit in carrying case.



Type AA Acetylene regulator as furnished with all Imperial welding and cutting outfits $22.50



Type C Oxygen regulator as furnished with all Imperial welding and cutting outfits $25.00

Welding and Decarbonizing Outfits.

No. 1 Imperial welding outfit: For all general welding work, from thin sheet metal to heaviest castings. Consists of type B welding torch with ten welding tips, extension, decarbonizing torch, regulators, gauges, hose, connections, goggles, complete supply of welding materials, ready for service. Weight, approximately 75 lbs. net, each..$75.00

No. 3 Imperial cutting outfit. Intended for light and heavy cutting, from sheet metal to heaviest iron and similar work. Consists of type E cutting torch with 2 housings and 4 tips, regulators, 4 gauges, hose, connections, goggles, hand-book, carrying case, etc., complete ready for service, net, each $95.00

No. 4 Imperial combination welding and cutting outfit: A splendid equipment for all general work, garages, repair shops, etc. Combination welding and cutting torch performs both operations with one torch. Consists of type B welding torch with type DB cutting attachment,, ten welding and three cutting tips, decarbonizing torch, regulators, gauges, hose, connections, goggles, complete supply of welding materials, ready for service. Weight, approximately 80 lbs. ....net, each $90.00

No. 5 Imperial duplex welding and cutting outfit: This is a combination of the Nos. 1 and 3 outfits for both welding and cutting and is the best all-purpose apparatus obtainable at any price. Being fully adequate to handle all kinds of welding and cutting within the limits of the process. Consists of a complete No. 1 welding outfit as described, and also includes a type E cutting torch with two housings and four tips and an extra pair of goggles and 25-foot lengths of hose. Weight, approximately 90 lbs. ....net, each $120.00

No. 6 Imperial oxygen decarbonizing outfit: For decarbonizing gas engine cylinders. Consists of type G decarbonizing torch, type D regulator, gauge, hose, connections, etc............net, each $15.00

The Imperial Brass Mfg. Co., 1200 W. Harrison St., Chicago.

CHART NO. 293-D—Oxy-Acetylene Welding, Cutting and Decarbonizing Outfits.

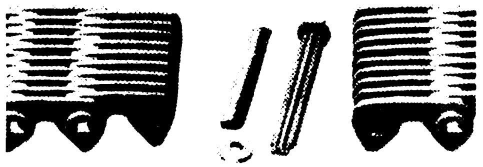


Fig. 1

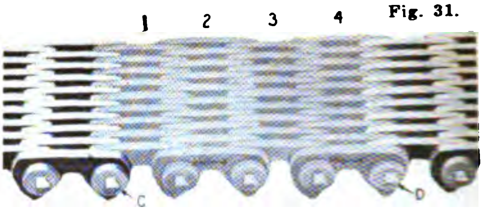


Fig. 31.

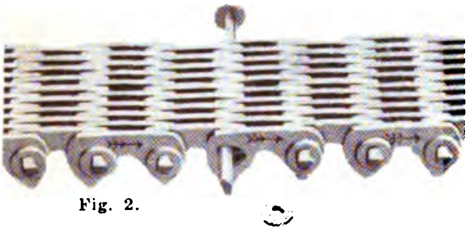


Fig. 2.

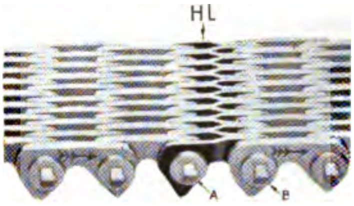


Fig. 21

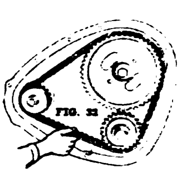


FIG. 32

Silent Chains.

Are used to drive cam shaft, generator, water pump, magneto, fan etc., instead of gears.

The Morse silent chain as used on many cars (enumerated below), is different from other silent chains only in that the Morse employs two pins in the joint, one called the "seat pin" and the other the "rocker pin."

To properly connect the ends of a Morse silent chain: Place chain over wheels to run in direction indicated by arrows. On all automobile front end drives, the arrow side of chain will be the near side, as shown in figs. 1 and 2.

Bring ends of chain together and lap the link plates in regular order as shown in fig. 2; insert "seat pin" (with washer riveted on one end) from far side of chain, taking care that the ribbed side of pin points in direction of rotation of chain as shown in fig. 2.

Insert "rocker pin" from near side of chain as shown by fig. 2, with segmental, or pointed, side of pin against flat side of "seat pin," also toward direction of rotation of chain. The relative positions of the two pins, when properly inserted, will be as shown by fig. 3, chart 294-A.

Place washer on end of "seat pin" and, after backing up with bar or wedge, rivet over the end with a few sharp blows of the hammer.

To shorten chain one pitch by removing the "hunting link." All chains containing an odd number of links must include the thin leafed section marked "HL" in fig. 21. This row of leaves (collectively) is called the "hunting link."

To remove same, move chain until the hunting link is on top of a wheel; then with chisel in vertical position and edge of blade at right angles to plane of washer, strike sharply with a hammer until washers A and B are split sufficiently to make them fall off. This releases pins in the two joints which can then be driven out and the leaf-plates of hunting link will fall away when chain is lifted up.

The chain is thus reduced in length one pitch (one link), and all that is necessary to put it again in running order is to bring the ends together, mesh the link plates in regular order and make proper connections as stated above. **The pitch of a silent chain is the distance from center to center of the pins.**

To shorten chain one pitch, by removing four links and inserting three, one of which is the "hunting link." Arrange chain with arrow side as the near side, either flat (as shown above) on some solid foundation or on top of one of the wheels.

Select a joint at the HEAD of an arrow, and, with hammer and chisel, cut washer C (fig. 31) until it falls off. Move to the right four links and cut washer D, also at HEAD of an arrow, in same manner.

Be careful that each severed washer is at HEAD of an arrow, as otherwise leaf-plates of three-link section will not mesh in regular order with chain.

Drive pins from joints C and D and remove links marked 1, 2, 3 and 4 in fig. 31. Insert a three-link section in place of removed section, making sure that arrow on new section points in same direction as arrows on old chain. Bring ends together, mesh leaf-plates in regular order and make connections.

NOTE—It is only necessary to remove four links and insert the section of three links, as described above where chains are used with an even number of links and do not contain a hunting link HL, fig. 21. If the chain contains a hunting link, it should always be shortened as described in instruction fig. 21.

Some of the engines on which Morse "front-end" drive is used: Cadillac; Chalmers; Clyde; Colonial; Drexel; Erie; Ferro; Gray; Hackett; Haynes; Hupmobile; Jeffery; Jewett; King; Lozier; Scripps-Booth; Monitor; Maxwell; National; Nash; Olympian; Pullman; Packard; Winton; Princess; Stearns-Knight.

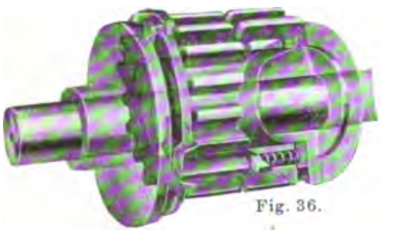


Fig. 36.

Chain Adjustment.

Various methods are used for adjusting chain tension: For instance, if chain drives generator shaft, the generator can be moved in slot holes to adjust chain tension, or shaft on which sprocket is mounted can be rotated on an eccentric bearing, or if mounted in separate case, shims can be installed under the case.

To adjust while running, tighten chain until noisy, then slacken to the point where noise ceases. Chain should be tight as possible without causing noise.

To adjust where cover is removed, as in fig. 32, take hold of chain and pull long strand as far as it will go to test the free movement. The total free movement will vary with the length between sprockets. If length is from 5 in. to 7 inches, the total free movement should be ⅜" to ½". If 8" to 11", ½ in. to ⅝ in. If it becomes noisy remove 2, 4 or 6 links each; never an odd number.

Morse adjustable sprocket, fig. 36 is designed for shafts, as generator shafts, etc., when shaft cannot be moved for adjustment. The sprocket (fig. 36) is mounted on a bearing which is eccentric to the shaft. By rotating the bearing, sprocket is moved, thus adjusting chain tension. The drive is through sprocket to a plate type universal joint at left end (fig. 36), to shaft. This joint also tends to relieve vibration of chain and is called a "vibration dampener."

CHART NO. 294—How to Connect, Shorten and Adjust the Silent Chain. (Morse as an example.) **An Adjustable Silent Chain Sprocket and Vibration Dampener.**

See pages 89 and 835 for remeshing timing gears using silent chains, also pages 411, 112 and 113.

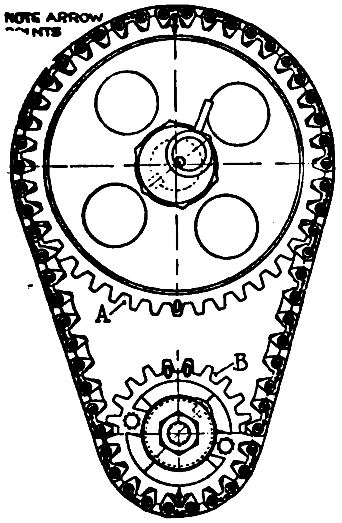


Fig. 4—The marks on the camshaft gear (A) should line up with those on the crankshaft gear (B), before the gears are removed, and should be replaced in exactly the same position

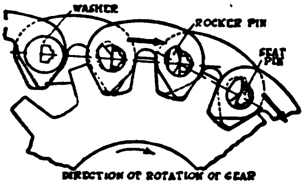


Fig. 3—In replacing the chains, make certain that the arrows point in the direction of rotation, and that the rocker and seat pins are in the position shown. Otherwise the chain will quickly ruin itself

Detecting Looseness.

Looseness in the silent chains grows so gradually that it is scarcely to be noticed until the chains have become so loose that they jump the teeth of the gears. This, of course, destroys the timing. **The amount of looseness may be felt** by grasping the generator shaft and rocking it back and forth. Any great amount of looseness destroys the proper timing of the valves and necessitates a replacement of the chains.

Disassembling.

After removing all parts so that access is gained to chains, then turn the engine until one tooth of the camshaft-driven sprocket, "A," fig. 4, which is marked with an arrow, is diametrically opposite the tooth with an "O." A tooth on the crankshaft sprocket "B" has a similar arrow upon it, and the two teeth opposite each have an "O" mark. All should line up, as shown in fig. 4.

Apply the special gear puller, as shown in fig. 2, to the crankshaft gear, next apply the special camshaft gear puller, as also shown in fig. 2.

Working both pullers together, remove both camshaft and crankshaft gear, at the same time sliding the distributer housing and fan drive chain forward. All will come off together. (The usual method is first to cut the riveted head of one of the seat pins on the driving chain, and remove the seat pin and rocker pin. The driving chain is then removed. In refitting the new chains by this method, it is necessary to rivet the seat pins while on the gears and in the case. This is a difficult and tedious job. By the method outlined in this article, the chains are riveted on the bench easily, quickly and with a certainty of its being right.) Place the gears, chains, etc., on the bench, removing the camshaft driving chain.

The Repair.

Cut off the riveted head of one of the seat pins on the fanshaft driving chain, and remove the seat pin and rocker pins. Remove the fanshaft driving chain. Clean all parts with gasoline and examine gears for wear. If worn, the faces of the teeth will be ridged, showing the marks of the chain links, and must be replaced.

Place new fanshaft chain over the fanshaft gear with arrows on outside links pointing in direction in which the chain is to run (fig. 3.)

Rivet a small washer onto one end of a seat pin in a vise. Bring the ends of the chain together. Insert a rocker pin, then drive the seat pin with its washer into place. Be certain the rocker pin and seat pin are in the position shown in fig. 3. Head over the end of the seat pin. Rivet up the new camshaft driving chain in the same manner.

Assembling.

Place the camshaft gear on the fan chain, with the mark "O" in the lowest position. Place the camshaft chain on the gear, with the arrows pointing in the direction of rotation. Place the crankshaft gear into the camshaft chain with the marks as shown in fig. 4. Now slide the whole assembly into place on the engine, driving the gears home with a brass bushing and machinist's hammer Replace nut and washer on crank shaft end and then replace parts which are disassembled.

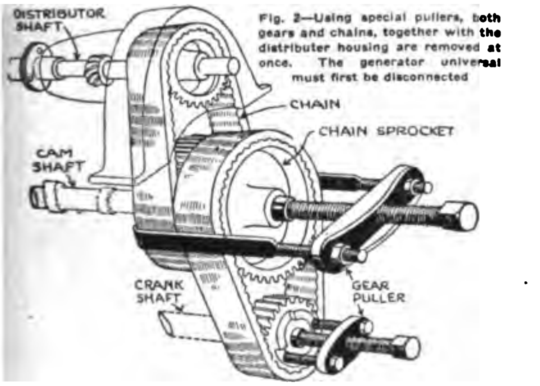


Fig. 2—Using special pullers, both gears and chains, together with the distributer housing are removed at once. The generator universal must first be disconnected

The Valve Timing.

The valve timing was automatically cared for in replacing the camshaft driving chain as directed, providing the valve tappets have the proper clearance. The exhaust tappet should have .003 inch clearance, the intake .002 inch; the exhaust should close and the inlet open on dead center. The inlet should never open at a point more than 1 in. on the flywheel, past dead center.

Ignition Timing.

Open compression relief cocks, crank engine until No. 1 cylinder (the one nearest the radiator, on the right hand side when facing the engine from the front) is on the firing center. The pointer above the flywheel will then be exactly over the mark 1-5 on the flywheel, and both valves of No 1 cylinder will be closed.

With the timer open, as shown in fig. 11, page 132, loosen lock screw (A) slightly. Then set spark lever as shown in fig. 5.

Connect test lamp into primary circuit, as shown in fig. 7. When the breakers are closed the light will be lighted, if the ignition switch be closed.

Replace distributor rotor and turn by hand until the distributor brush is under the terminal marked No. 1 on the distributing cover. Turn on the ignition switch. The light should light. Turn rotor very slowly, in the direction it is driven by the engine, until the lamp goes out. Remove rotor, tighten screw (A) of fig. 11 (page 132).

Replace rotor and retard spark. Then move the spark lever slowly back toward the point of the arrow, as shown in fig. 5. When the point of the arrow is reached the light should go out. If not, reset rotor and cam as directed.

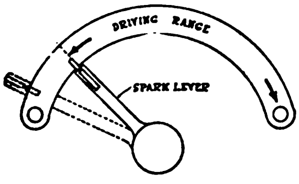


Fig. 5—Position of the spark lever, when timing the ignition. The end of the lever on the quadrant should line up with the point of the arrow as illustrated

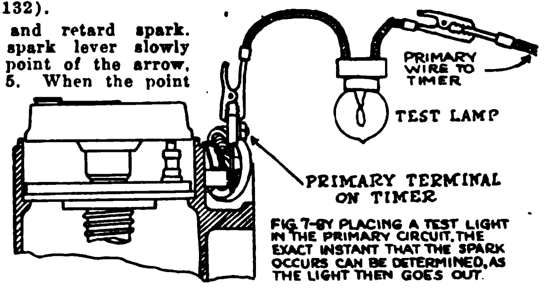


FIG. 7—BY PLACING A TEST LIGHT IN THE PRIMARY CIRCUIT, THE EXACT INSTANT THAT THE SPARK OCCURS CAN BE DETERMINED, AS THE LIGHT THEN GOES OUT.

HART NO. 294-A—Replacing Silent Chain. Valve and Ignition Timing on Cadillac.

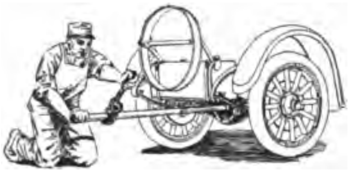
hain alignment—when tightening a silent chain by movement of generator—if it is not moved in perfect alignent it will cause chain and sprocket to wear rapidly. This is most important. See also pages 128 to 133

INSTRUCTION No. 46-D.

USEFUL SHOP HINTS AND DEVICES: Labor Saving Short Cuts in Repairing. Time Savers for the Shop. Miscellaneous Shop Kinks. Tools for Straightening Fenders, Etc.

Miscellaneous Shop Devices.

This section is intended for miscellaneous shop hints, useful and time saving devices and methods for the shop. The material is collected from various sources. The writer has not tried out any of the examples shown but having taken same from reliable journals, the matter is evidently practical and many different repair jobs can no doubt be made easier or quicker by the use of them.



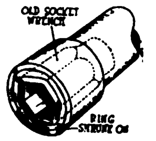


*Fig. 1—Extension socket wrench: By mounting a socket wrench head in the end of a 4 ft. length of 2-inch pipe, an extension wrench is made that facilitates the removal or replacement of the nut on the rear axle drive pinion. A steel ring is first shrunk on the end of the pipe, to provide strength, the pipe is heated red, and the cold socket wrench head driven into the pipe. When cool, the head is firmly held in place. Because of the long handle, a pipe wrench may be used to get a leverage, and the workman may work from an uncramped position.

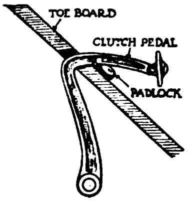


Fig. 2—One method of locking a car. Hole is drilled in clutch pedal arm for the insertion of a padlock. Prevents use of clutch.

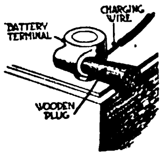


Fig. 2A—To attach charging wires to batteries where charging is done continuously, a wooden plug is handy.

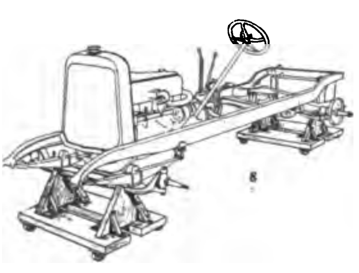


Fig. 3—Axle stand: Work is facilitated by the use of this special stand. The one illustrated is fitted with rollers and permits the chassis to be moved about, rendering the parts more accessible.

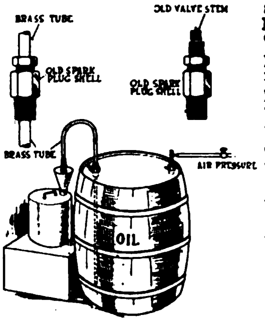


***Fig. 5—It is difficult to transfer oil from the common oil barrel to a smaller container unless some special outfit is at hand, such as illustrated.** The oil is forced by air pressure from the barrel. Air pressure is applied through a valve that is an ordinary tire valve soldered into an old spark plug shell, which in turn is screwed into a hole in the barrel. The oil is delivered through a bent brass pipe, passing through a second spark plug bushing, also screwed into a hole in the barrel. This pipe must be long enough to extend nearly to the bottom of barrel, as shown by dotted lines. Packing is placed between the bushing of the plug and the shell, so that the tube may be adjusted to any barrel, and the amount of oil is readily regulated by the pressure applied.

Fig. 6—A self-opening repairshop door is shown. The door is of the sliding type, hung on a horizontal track, but counterbalanced with weights swung over a pulley so that it automatically opens when the catch is released. This catch is of the hook type, and connected with a hinged board placed across the roadway, the car itself releasing the catch and allowing the door to open. One of these hinged boards is placed both on the inside and the outside of the door, so that one entering or leaving has only to get out of the car once.

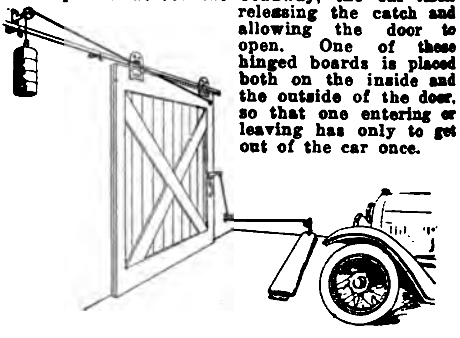
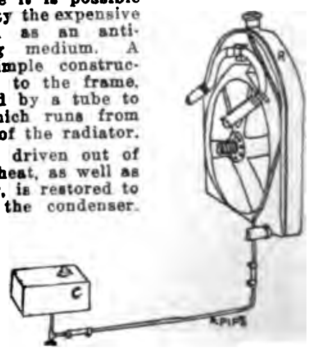


Fig. 7—Cadillac patented condensing device: With this device it is possible to use with safety the expensive alcohol solution as an anti-freezing cooling medium. A condenser of simple construction is attached to the frame, and is connected by a tube to the overflow which runs from the upper tank of the radiator.

Alcohol vapor driven out of the solution by heat, as well as any water vapor, is restored to liquid form in the condenser.



When the radiator gets cold, the vacuum produced by the contraction of its contents automatically causes surplus liquid in the condenser to return under atmospheric pressure to the radiator. (This device is patented and merely shown to explain the principle.)

---

*From Motor World.

Straightening Bent Frames, Etc.

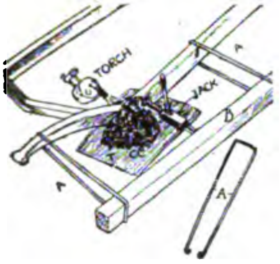


Fig. 1.

Fig. 1—Straightening a bent frame: To make the repair, the radiator is removed, a pan of charcoal placed under the frame, and pieces of charcoal heaped around the bend as shown; the frame is then heated up about the bent portion by playing upon the pile of charcoal with the flame of a blow torch.

As the frame is brought to a cherry-red heat the device A is applied and used in connection with a wooden beam B which supports the jack.

The torch now is set aside, the charcoal removed, and while one man carefully operates the jack and slowly draws the bent member back to its proper shape. another assists the operation by tapping and shaping the heated section with a hammer.

This hammering is quite necessary and an important factor in bringing about a successful result as it assists the molecular action of the steel, and prevents the end of the frame from springing back out of line as the job cools off.

The entire straightening process must be done while the injured section is red hot and the job completed before the red color is lost.

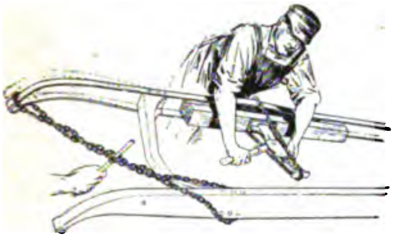


Fig. 2.

Fig. 2—Bent frame horns may be pulled back into place by a chain, providing the force is applied in the proper place. The method of attaching the chain is shown, and the force is applied by twisting the chain with a steel pinch bar. A jack, placed against wooden blocks and with a chain sling over it as shown. may be used to straighten the side members of the frame.

Fig. 3—Frames may be straightened without heating and sometimes without even dismantling the car by means of the simple device shown. It consists of a wooden beam 4 in. x 6 in. x 5 ft., reinforced with iron ¼ in. thick on each side. The beam forms the base of the device, to which are attached the steel arms which fasten to the frame. A powerful jack is used to apply the required pressure to bring the frame back to normal. A chain may be substituted for either of the arms.

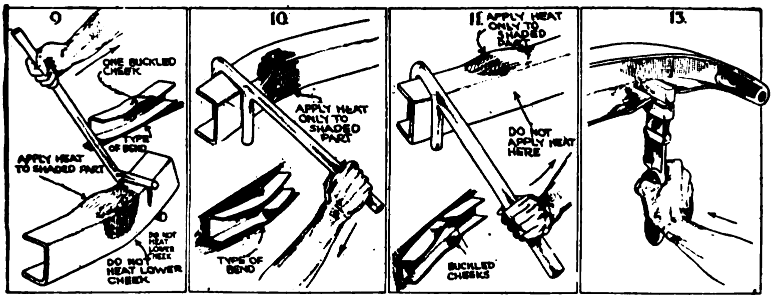

9
ONE BUCKLED CHEEK
TYPE OF BEND
APPLY HEAT TO SHADED PART
DO NOT HEAT LOWER CHEEK
DO NOT HEAT LOWER CHEEK
10
APPLY HEAT ONLY TO SHADED PART
TYPE OF BEND
11
APPLY HEAT ONLY TO SHADED PART
DO NOT APPLY HEAT HERE
BUCKLED CHEEKS
13

Fig. 9—When one cheek and part of the face is buckled, only the bent parts should be heated. Fig. 10—When the face is buckled very little heat should be applied to the cheeks. Fig. 11—When both cheeks are buckled heat should not be applied to the face but to the shaded portion. Fig. 13—Small crimps may be taken out with heat and a monkey wrench

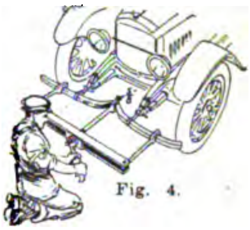


Fig. 4.

Fig. 4 — Straightening dents in bumpers and similar articles can be done in minimum time with the device illustrated. It is not necessary to remove the bumper from the car. The central member, which does the pulling, may be slid from one end to the other, as required, so that a dent in any part of the bumper may be removed.

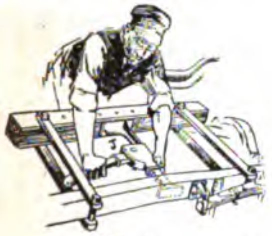
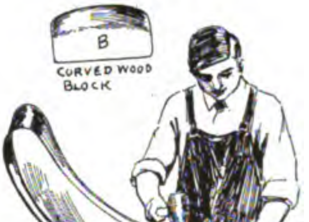
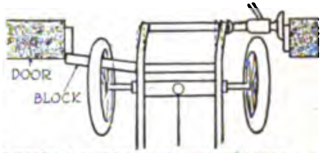


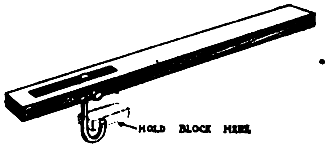
Fig. 3.



Easy method of removing dents from fenders with the use of a shaped wood block



Another method of straightening a bent frame.



A fender straightener made of oak 3x4, 4 ft. long.

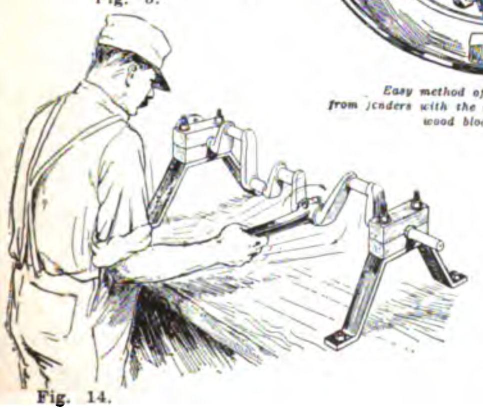
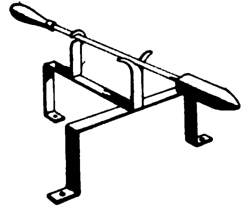


Fig. 14.

Fig. 14—**A wooden crank shaft support** for fitting connecting rod bearings to crank shaft when removed from engine.

Fig. 15—**A Soldering iron stand** which can easily be made and well worth the time.



HART NO. 295—Straightening Bent Frames. Straightening Bumpers, Fenders, Etc. (see als page 745.) **A Car Lifting Device.**

Motor World.)

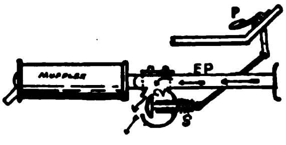


Fig. 3—Fitting a muffler "cut-out." Mufflers sometimes are not large enough or are clogged up and offer "back pressure" or resistance to the full passage of the exhaust. A "cut-out" is helpful in climbing hills and to help keep engine cool. The muffler cut-out is also a convenient method of ascertaining (by listening), whether all clyinders are firing regularly.

Muffler "cut-outs" are installed by cutting a hole in the exhaust pipe just ahead of the muffler. Fittings can be had from supply houses ready to fit and with full instructions. (see also page 84 and page 608.)

Attention to the cleaning of the muffler must not be lost sight of, for this is a point having a great effect upon efficiency. For open cars the writer considers a cut-out a necessity; not for roaring through towns or villages, but for the purpose of testing the firing and carburetion.

Although it is necessary to remove the muffler for a thorough cleaning, it is quite possible to effect a satisfactory temporary cleaning of the badly obstructed passages by tapping its sides all over lightly with a hammer or mallet. The result will be that much sooty accumulation will be knocked off and blown out through the tail pipe.

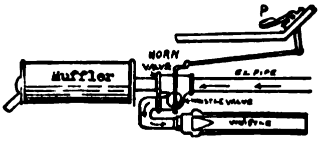


Fig. 4—Fitting an exhaust whistle: The exhaust whistle is blown by the exhaust pressure, for instance; instead of the exhaust going out into the open air, as in muffler cut-out, fig. 3, it passes into the whistle.

When fitted to an exhaust pipe the exhaust is temporarily cut off from the muffler and thrown into the whistle by a special valve attached to the exhaust pipe. Multiple engines blow a whistle almost steady, but single and double cylinder engines blow in jerks or uneven blasts.

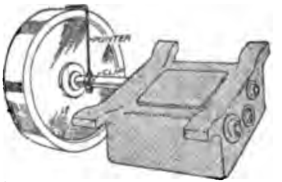


Fig. 3 Device for centring shafts of gearbox and clutch.

Fig. 3—Testing shaft alignment: When the engine is overhauled the setting of the crankshaft with respect to the gearbox shaft should be carefully tested. The simplest way to do this is to arrange an indicator on the gearbox shaft, as shown in the illustration. This consists of a stiff, straight piece of wire clipped to the shaft, and then bent at right angles in the form of a pointer. If the centers of the shafts exactly coincide this pointed end will clear the edge of the flywheel an equal amount all round. If the centers are slightly out of alignment the pointer will be nearer the flywheel edge at one part of its circumference than at another. By having a sliding adjustment to the pointer a very accurate setting can be made. The gearbox can always be slightly packed or raised by means of very thin sheet metal shims, placed under its supports, to effect any adjustment required.

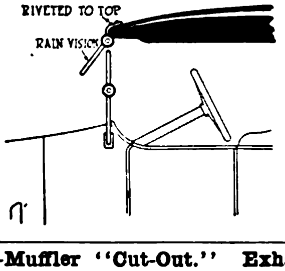


Fig. 6—Rain vision windshields are common on closed cars but unusual on open ones. It is a simple matter, however, to add this feature. The upper section of a windshield is mounted on the front of the top, two specially made brackets being used to hold it in place. It catches the rain and the regular windshield protects the driver from the wind.

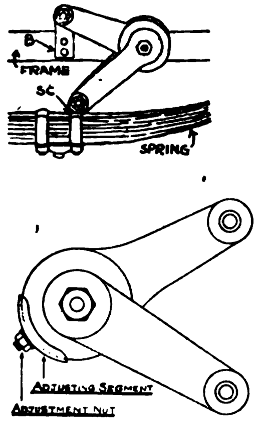


Fig. 7—Attaching Connecticut shock absorbers: Shock absorbers are necessary accessories. They prevent the rebound of springs after the spring action and thereby prevent springs being broken by the sudden up motion of car which is common in going over crossings, etc.

If properly fitted, they are worth many times their cost. To fit—first fill the grooves inside the bushing in the end of each arm with graphite grease.

In order to secure satisfactory results it is important that the angle of the arms be correctly adjusted so that the cam which operates against the springs in the absorber will be in normal position when the car is loaded and standing still.

Care should be taken that the absorbers are so located that they will not strike the frame when the car is in motion. After the fittings have been attached, slip the absorbers on to the studs of the fittings by loosening up the adjustment nut, so that the arms can be pulled apart any desired distance.

Load the car with full number of passengers the car is designed to carry and tighten up the adjustment nut. The lock washer should be on the stud and the nut tightened securely so that there will be no danger of the adjusting segment slipping. See that the cotter pins are all in place in the end nuts.

After the absorbers are attached no further adjustment or attention is required. (Manufacturers are Connecticut Shock Absorber Co., Meriden, Conn.) See page 26 for other types.

Fig. 30—A tow-bar whereby two cars may be brought in by one driver. A towing bar, attached to the rear of the driven car, pulls the towed car by a clamp in the front axle. The bar extends behind the axle, and a stud on a clamp on the tie rod goes in a hole in the bar. In this way, when the bar turns, it moves the tie rod, and the towed car follows its leader.

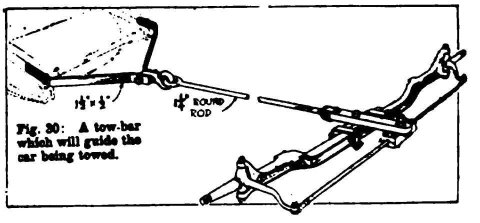


Fig. 30: A tow-bar which will guide the car being towed.

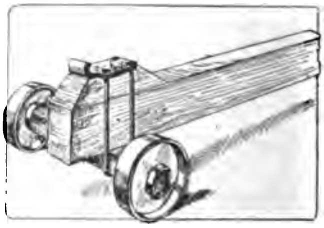
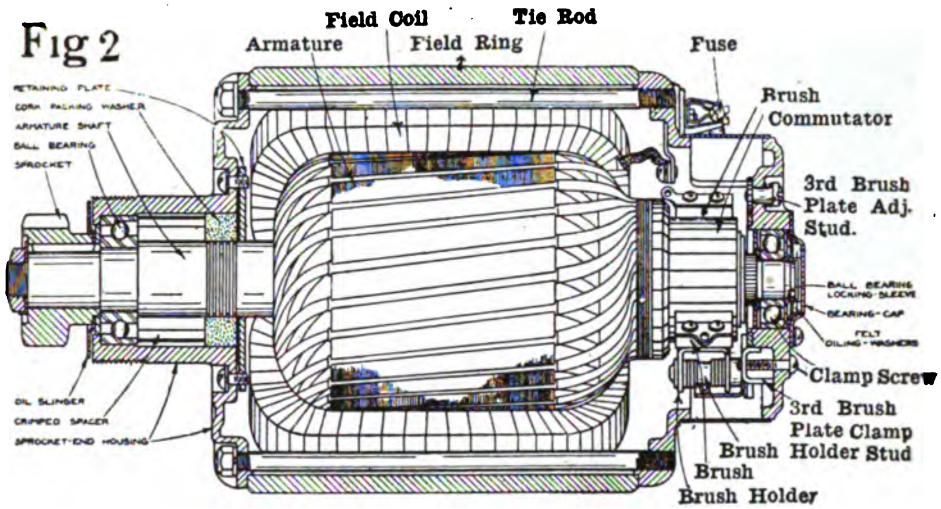


Fig. 9—Towing truck consists of two heavy metal wheels 10 inches in diameter and with a rim 2 inches wide, on which is mounted a tongue about 10 ft. long. Directly above the axle is a hook-shaped member for engaging the axle of the car.

A towing pole is superior to a towing rope for bringing in disabled cars, for the reason that it keeps the cars at an even distance, there is no danger of one running into the other.

CHART NO. 295-A—Muffler "Cut-Out." Exhaust Whistle. Testing Shaft Alignment. Fitting Shock Absorbers. Towing Trucks.

Fig 2



Third Brush Adjustment.

Turn 3rd brush plate adjusting screw in rear of generator just below fuse (fig. 2), in anti-clockwise direction for greater charging rate. This moves brush in direction of rotation. To decrease, move screw clockwise, see also pages 370, 924.

Shunt Field Fuse.

The fuse (fig. 2 above and page 370), is located on the outside of the commutator-end housing of the starter-generator is inserted in the shunt field circuit; and is designed to blow if the battery circuit is opened, thus protecting the system by rendering the starter-generator inoperative.

Therefore, if the machine fails to charge the battery at any time, inspect the fuse first of all; and, in case it is found blown, replace it with a new one. If the new fuse in turn blows as soon as the machine is started up, make a careful search for the cause of the trouble before running generator again.

Removal of Armature.

1—Remove four nuts on sprocket end of generator and pull plate off with armature; 2—undo pinion sprocket nut and pull pinion off; 3—remove bearing back of sprocket, which comes off when the armature is driven out of the plate. The front armature bearing is lubricated automatically from the chain.

To Remove and Replace Chain.

1—Remove housing enclosing starter-generator pinion; 2—turn engine over until master link is exposed; 3—break master link and attach both ends of new chain to old chain; 4—crank engine over until new chain is in place, when old one may be removed and master link of new chain closed; see also pages 411, 369 and 728.

To Adjust Chain.

See page 369 and illustrations, fig. 1, below and pages 411, 728.

Oil Adjustment.

1—Oil gage on dash should show pressure of 2 to 4 lb. at 20 m.p.h.; 2—if pressure is too low or too high and investigation shows that adjustment is required, then remove springs in by-pass located directly in front of the water pump, stretching it for more pressure or cutting it off to give less pressure.

To determine whether oil is flowing through feed pipe inside crankcase when gage does not work, it is best first to remove oil inspection plug just beyond the lower rear corner of the rear valve cover plate. If oil spurts out at this point with engine running it shows that trouble is in the gage.

Carburetor Care.

To clean metering pin, undo bottom nut on carburetor (page 178), withdraw pin and wipe off with a rag moistened with hydrochloric acid.

If air valve sticks, the air valve stem may be dirty. move carburetor mixing chamber and bottom flange and unscrew the two parts of the valve. When apart, wipe stem, or neck of air valve which slides in a guide in the body of carburetor with a rag, moistened with hydrochloric acid. **Adjustment of carburetor** is explained on page 178.

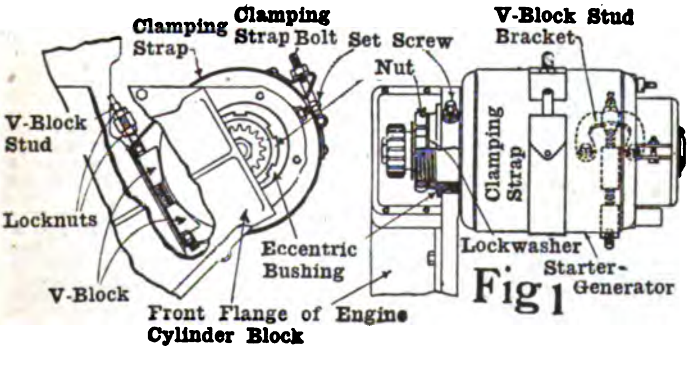


Fig 1

HART NO. 296—Dodge Starter-Generator Adjustments—see also pages 396, 370, 924. For ad ustment of Dodge Clutch, Brake, Rear Axle, etc., see pages 931, 932, 666, 689. (Motor World.)

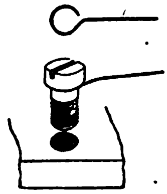


Fig. 1—A simple method for inserting screws in inaccessible places.

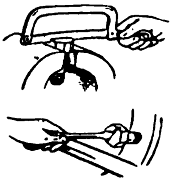


Fig. 2—Cut a slot in a cap screw head with a hack saw and use screw driver—to start cap screws in inaccessible places

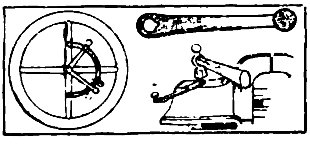
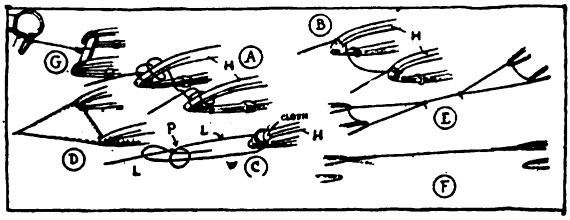


Fig. 3—Showing method for tightening a loose throttle control lever. Remove the lever from the car, place it on the anvil portion of the vise, strike it a few sharp blows with a hammer, as indicated in the illustration, whereupon, on refitting the lever to the end of the rod, instead of fitting loosely, it will be necessary to force it on by tapping it into place with a hammer, the nut then be replaced and the trouble eliminated

Two hack saw blades mounted side by side will cut a wider slot.



In fig. 2 are shown some right and wrong methods of securing the tow rope to the vehicle to be towed. The best way is shown at G, a piece of wood being tied under and across the frame horns as illustrated, and a single rope connecting it to the rear of the towing vehicle.

To loop the rope under the frame as at D is very bad, as a severe strain would bend the horns inward.

The bowline knot is the best to use at all times as it is easy to make and as easy to untie; it is illustrated at C. In the same illustration, attention is called to the cloth wrapped about frame to prevent chafing.

When a bar of wood is not readily obtainable, and a heavy car is to be towed, the rope may be secured as illustrated at B; two half hitches being used, as shown at A, to secure the rope to the horns of the frame, and the rope between the two horns being left slack. When using this method, the bights also should be as long as possible. Two long bights are shown at E; whilst an undesirably short bight is depicted at D. A shows how the two half hitches are made, and B shows how they look when drawn taut, the slack being shown in the rope between the horns H to prevent their being drawn together.

The knots at A and C are the most useful. Their advantage over other knots is that they will neither slip nor jam.—From Motor Age.

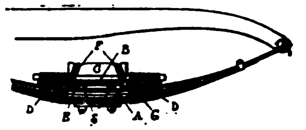
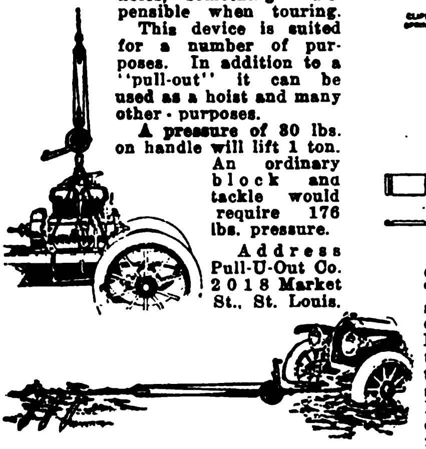


Fig. 3—A temporary spring repair: In fig. 3 is shown how a temporary repair was made upon a spring whose three lower leaves were broken on striking an apparently shallow hole in the road which was filled with water. After the break A occurred, the car was slowly driven to the next farmhouse, where some 2 by 4 blocks, a saw and some baling wire were obtained. The short block E was cut off first and two shallow grooves S were cut into one side of it so that it would clear the spring clips and rest flat on the central portion of the top spring leaf. The sides of these slots were cut with a saw and then finished up with a cold chisel carried in the tool kit of the car. The piece B then was cut off and nailed to the short piece E, so that the sides were flush and its ends extended over the ends of the short block equally distant on either side. The top block C, which was made just a trifle longer than the short bottom block, was cut off and slotted in the same manner as the under block, only the slots were not so wide and farther apart as designated by the letter F. This block then was nailed to the long piece, centrally located with the slots up. The frame of the car was then jacked up so that the injured end of the spring was a little above its normal height, and the blocks were set in position as shown and securely bound into place with the wire D. When this was done a few strands were wound about the two top pieces, as at F, to add to their security; then a few more strands were bound laterally around the whole, as at G. This completed the temporary repair.

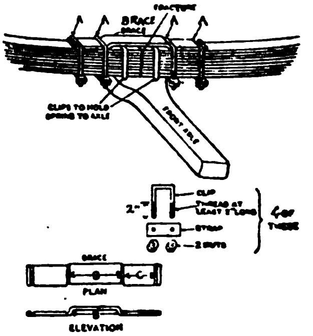
A block and tackle consisting of two double-sheave pulleys and a 1¼-in. rope will be found of considerable assistance in wrecking work. It may be used for raising a car when there is a tree available, and it is particularly good for pulling a mired car out. One of the pairs of pulleys is attached to a tree or some other substantial object, the other pulley fastened to the car that is in difficulty, and the free end of the rope tied to the tow car.



The Pull-U-Out is a very powerful and satisfactory device for pulling cars out of mud holes, something indispensible when touring. This device is suited for a number of purposes. In addition to a "pull-out" it can be used as a hoist and many other purposes.

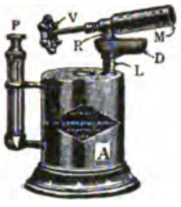
A pressure of 80 lbs. on handle will lift 1 ton. An ordinary block and tackle would require 176 lbs. pressure.

Address
Pull-U-Out Co.
2018 Market
St., St. Louis.



Another temporary repair on an automobile spring: The width of the brace should be equal to the width of the spring and the part B long enough to lay over the clips holding the spring to the axle. The ends C should be about 3 inches long. Such a brace will effectually repair either a front or rear spring.

*How To Operate a Gasoline Torch—single jet type.



Fill about ⅔ full of gasoline; filler plug on this type is at bottom of tank (A). The torch is turned up side down, gasoline poured in and plug screwed up tight, being sure it does not leak.

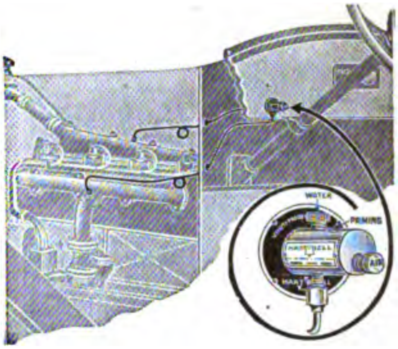
Air is then pumped into tank (A) by air pump plunger (P), being sure gasoline valve (V) is closed. Then hold hand over mixer tube (M) and slowly open valve (V)—gasoline will drip into heater (D). Light this gasoline with valve (V) closed. This heats the pipe (R). After the gasoline in heater (D) has burned up, the heat should be sufficient to vaporize the gasoline causing air and gasoline to flow through pipe L & R from tank (A) to burner or mixer (M) when valve (V) is opened. A match is applied to this mixture and should be blue in color—if yellow then heating is not sufficient and operation must be repeated. It is advisable to protect the flame from wind when heating.

All torches work on the same principle. Some, however have two valves, as per page 711, fig. 1, which is termed a "double-jet." They are also constructed with pots over the flame for melting lead in, these are termed "fire pots."

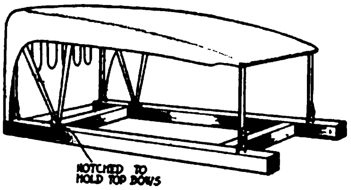
For brazing a similar principle is used except a larger tank and burner and separate air pump which pumps 75 lbs. into tank—see page 712.

A Carbon Remover and Water Injection.

Fig. 12—This device, it is claimed will remove carbon by injection of steam into inlet manifold which loosens the carbon and permits it to be blown out the exhaust. **It also admits air directly into the combustible mixture,** which means more complete combustion or power. (Hart-Bell Co., 1926 Broadway, N. Y.)



It is often desired to paint or repair a top without leaving the car in the repair-shop. A simple support that permits this is a rectangular wooden framework notched to hold the top irons. The top is placed on this framework.



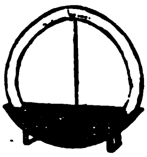
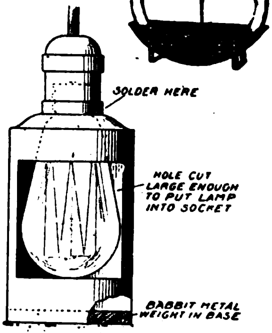
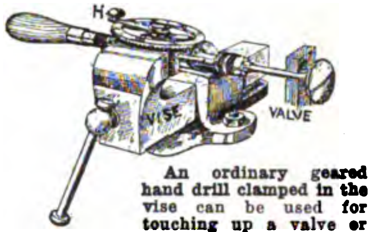


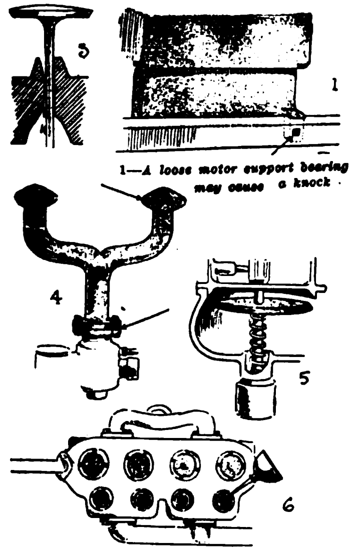
Fig. 20—A tank for testing inner tube leaks for tire repair shop is shown to the left. It is 6 ins. wide and 8 ins. deep.


SOLDER HERE
HOLE CUT LARGE ENOUGH TO PUT LAMP INTO SOCKET
BABBIT METAL WEIGHT IN BASE

A shop light, made of a can protects the globe and not easily turned over.



An ordinary geared hand drill clamped in the vise can be used for touching up a valve or filing a taper pin when a lathe is not available. A wood "rest" or steadying piece must be placed behind the valve. It can be fixed by a screw or clamped to the bench.



1—A loose motor support bearing may cause a knock

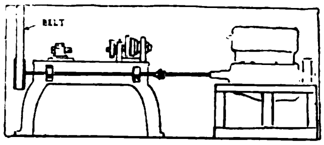
Common Cause of Misfiring

3—A worn valve guide leaks oil and permits extra air to be sucked into the cylinders.

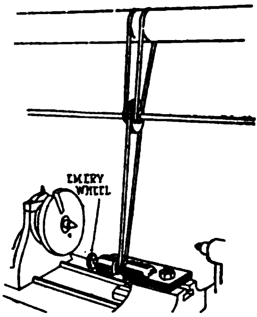
4—A turned or broken gasket may cause an air leak

5—A sticking air valve will cause misfiring and perhaps backfiring

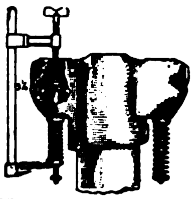
6—The cause of misfiring may often be traced to leaky cylinder plugs



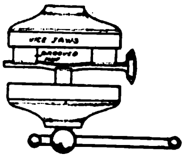
For "running engines in" after they are overhauled the simplest arrangement is probably to connect the front end of the crankshaft to a shaft driven by belt from the line shafting. This coupling may be of the starter crank type. The engine should be supported on a low stand and the driving shaft should be provided with a universal. The shaft is most simply mounted by bolting it to the legs of a lathe or planer, as illustrated, and the shaft is driven directly from a pulley on the line shafting. (see also Ford Supplement.)



A very small grinding wheel for mounting in a lathe may be used for fine work. The wheel is approximately 1 in. in diameter and runs several thousand revolutions per minute, this speed being obtained by a double belt reduction from the driving drum. The intermediate pulley really floats in the air, the shaft it slides on being merely to hold it in case one of the belts should break, thereby destroying its equilibrium.—



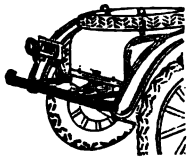
Home made valve spring lifter.



Method of straightening a bent shaft or rod such as a valve stem. The vise is used as a lever. The supports are grooved and adjusted to suit the bend.

CHART NO. 298—Miscellaneous Shop Hints.

*See pages 711. 712 and 696 for a gas heater.

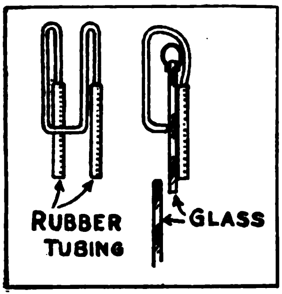


A bumper in the rear as well as the front is now the approved method. The Emil Grossman Mfg. Co. of Bush Terminal, New York, manufacture the bumpers for the rear or front. Write for catalog.

GOOD WINDSHIELD CLEANER.

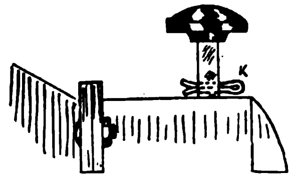
One of the essentials of bad weather driving is some provision for keeping the top glass of the windshield free from snow or rain. Chemical preparations are sometimes used to give the surface of the glass a greasy surface, so that the rain will run off rapidly, but this method is not effective against snow.

Scraping off the surface of the glass is perhaps the most effective method yet devised.



A simple cleaner may be made of a piece of rather heavy steel, or brass, wire about a quarter of an inch in diameter, and a piece of rubber tubing. The wire is bent in the form of a double loop, and a piece of rubber tubing is slipped over each free end of the wire. If the wire is coated with rubber cement, before the rubber tubing is pulled on, there will be no chance for the tubing to come loose.

The middle of the wire loop should rub on the inside of the glass at a point about opposite the middle of the rubber tubes, so that an even pressure will be exerted by the rubber tubes over their whole length on the surface of the glass. (Fordowner.)



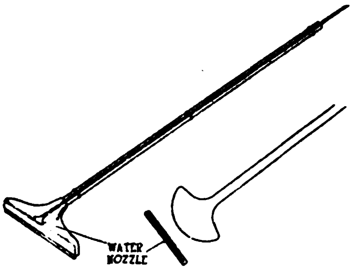
Silencing Mechanical Horns.

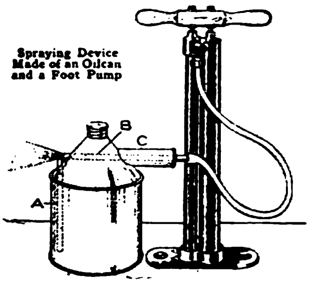
Car owners are often annoyed by small boys who persist in sounding the mechanical horn when the car is left unattended. A simple, but effective, method of discouraging this practice consists of drilling a small hole through the plunger rod and slipping a cotter pin through this hole when the car is left alone.

While the cotter pin may be easily removed when the owner of the car returns.

Window Cleaner.

For removing dust from windows the ordinary rubber edge window dryer combined with a nozzle which gives a flat spray the full length of the edge, may be used with a considerable saving of time. The nozzle is made from a piece of copper pipe, which is flattened and flared, as shown, and is then strapped to the handle. The water is turned on and the tool is rubbed up and down the window surface, thus removing all dust and dirt; then the water is shut off and the window is dried by scraping the drops away —





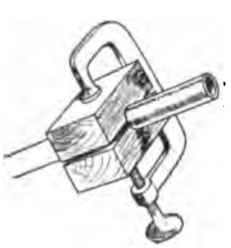
Spraying Device Made of an Oilcan and a Foot Pump

Painting an Automobile Radiator

Painting an automobile radiator quickly and thoroughly with a brush is difficult. A homemade spraying outfit similar to the one shown in the illustration made the job easy.

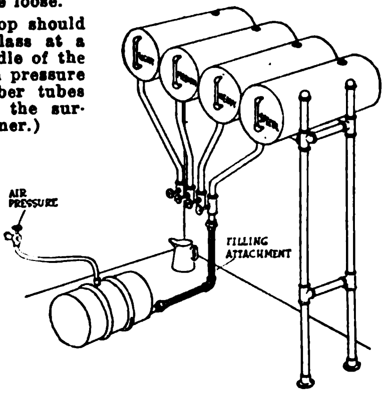
The outfit consists of a ½-gal. oil-can, made into an atomizer by attaching a tire pump to the end of the air pipe B. A piece of small brass pipe, A, was mounted in one side of the can, the upper end of it extending a short distance outside of the top. A second piece of pipe was mounted in a horizontal position in the top of the can, as shown at B. If a handle is attached to the can, as at C, the piece of pipe B may pass through it lengthwise and extend a short distance beyond the end of the handle. Both pipes were soldered to the top of the can, and the screw top was provided with a gasket to make it tight.

When the air is forced through the horizontal tube B and caused to pass across the opening in the upper end of the vertical tube A, the liquid in the can is drawn up and forced out in a fine spray. A mixture for spraying the radiator may be made of lampblack and turpentine. A sheet of paper should be placed back of the radiator to protect the engine, and around the outer edge, to prevent the liquid from bespattering the brass finish.



STEERING POST PULLER

Two wooden blocks clamped to the steering post by a heavy metal clamp offer a convenient brace for a jack, thus permitting the removal of the steering post. After applying a strain to the post by means of the jack, a few blows on the blocks with a heavy hammer so loosen the post that it may be drawn out without injury.—



OIL STORAGE SYSTEM

An oil storage system whereby the oil is discharged by gravity, is shown. It comprises several tanks, as many as there are kinds of oil to be stored, held close to the ceiling on pipe standards, and each pipe connected to its discharge valve. Oil is transferred from the original barrel by air pressure, through a special connection, in the manner illustrated. In addition to facilitating the withdrawal of oil, this method gets the storage tanks up out of the way, and saves much valuable room.—

Rough surfaces, such as garage walls, may be painted or whitewashed quickly and economically by the use of an air spray similar to that used for cleaning motors with kerosene. The paint or whitewash is placed in a bucket and the application of air pressure to the nozzle, whose construction is plainly shown, atomizes the liquid and sprays it against the walls. Valves are provided for regulating both air and liquid flow, and with a little experience it is easy to obtain an adjustment which will allow an even and economical application of paint.—

CHART NO. 299—Useful Shop Hints and Devices.

When a large gearbox is to be taken out of a car, it usually means that more than one man must be employed, as the weight of the box, together with the awkward position it is in, makes it difficult for one man. In such circumstances the chain hoist shown will be well worthwhile. Two steel bands pass under the gearbox to support it, and by using the chain hoist one man can lower the gearbox to the floor or vice versa. The chain hoist also gives a means of obtaining slight adjustments which are required in putting the box back in place.

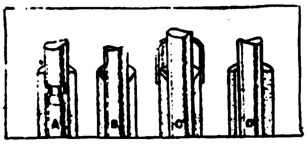


Fig. 4—Four methods of preventing oil loss from valve tappet guides

Many engines lose oil from the tappet guides, and in Fig. 1 are four methods of dealing with this nuisance.

In method A the tappet itself is doctored, a groove being ground in the center. This groove is of peculiar design, the upper portion being sharp cut and the lower part gradually chamfered, the idea being that the oil escaping past the rounded portion is met by the sharp edge when the tappet is descending, and is forced down with an action similar to the scraper ring on a piston.

In B a deep recess is countersunk in the top of the tappet guide, and forms a slight well where oil can accumulate. If there is still a tendency for the oil to overflow, the idea can be carried a step further, and we arrive at Fig. C, where the well has been increased by soldering to the top of the guide a collar made from a piece of brass tube $\frac{3}{8}$ inch in depth and of such diameter as to be just slipped over the head of the guide.

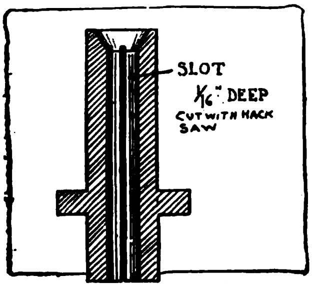
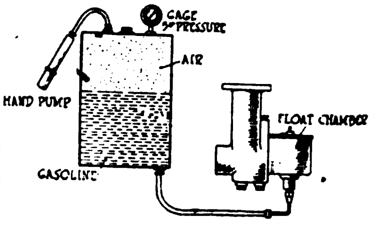


Fig. 8 or (D)—Leakage of oil from push rods prevented by a slot $\frac{1}{16}$ inch filed full length of guide.



FLOAT VALVE TESTER

This illustration shows a device for determining whether the float valve of the carbureter leaks. It is designed particularly for pressure systems, although it may be used for the ordinary gravity system by simply removing the pressure. It consists of a tank partly filled with gasoline and provided with an air gage and hand pump. The carbureter is attached, the pressure raised to the required amount, and then the carbureter is allowed to stand for several hours to determine whether any leakage takes place. Float valves which may not leak at all when tested under a small gravity head, will leak badly when put under a few pounds pressure.—

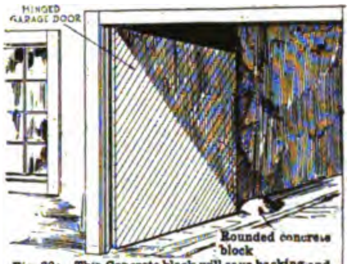
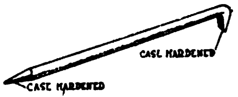
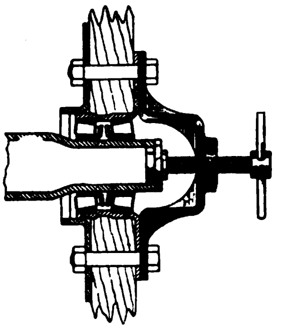


Fig. 30: This Concrete block will save backing and driving into door.

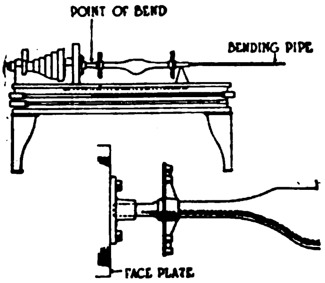


A pinch bar 18 in. by $\frac{5}{8}$ in., handy for removing gears, etc.



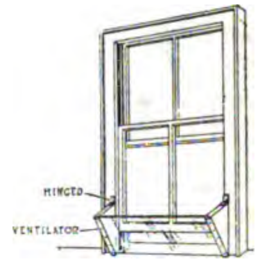
REAR WHEEL PULLER

A special puller is required for the removal of the Dodge rear wheel. After the removal of the outside flange and the rear axle, the frame of the puller is bolted onto two of the flange bolts. The plunger on the end of the screw fits inside the rear axle, housing, giving a leverage that permits the ready removal of the wheel. The frame is made of cast iron, reinforced by ribs; the screw is a $\frac{3}{4}$-in. bolt.



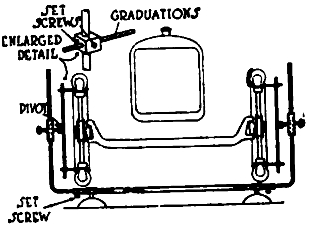
AXLE STRAIGHTENER

A bent rear axle housing may usually be straightened in a heavy lathe by supporting the axle in a fixture on the face plate at one end and bending it back to shape by inserting a piece of pipe in the other to give increased leverage. The bent end of the axle should be placed next to the fixture. Obviously, when the axle is perfectly true it will rotate evenly on its axis. The fixture is a heavy casting bolted firmly to the face plate and with a hole which snugly fits the axle end. Different size axles may, of course, be accommodated by using different size bushings.



WINDOW VENTILATOR

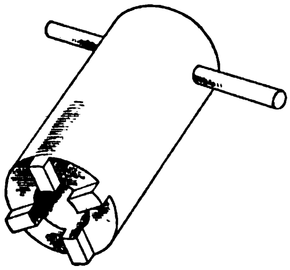
Some method of ventilating the repairshop should be provided, and a simple form of window ventilator is shown. It consists of a piece of an old windshield glass, held in an inclined position on the window sill by two triangular supports, and permits the window to be raised and the shop ventilated without causing a serious draught on the mechanic.-



WHEEL ALIGNING FIXTURE

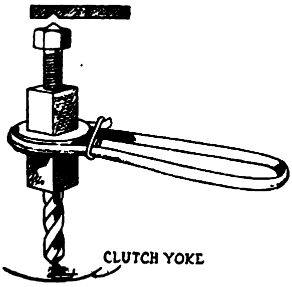
The alignment of either the front or rear wheels may be tested by this fixture. The frame is made of wrought iron pipe, and is adjustable by means of sliding joints. The feature of this fixture is that both sides of the wheel are tested at the same time; the camber and amount the wheels toe in can be readily determined. The front wheels should toe in from $\frac{1}{4}$ to $\frac{3}{8}$ in.— .

CHART NO. 800—Useful Shop Hints. See also pages 682 and 683 for alignment of wheels.
Chart 301 omitted.



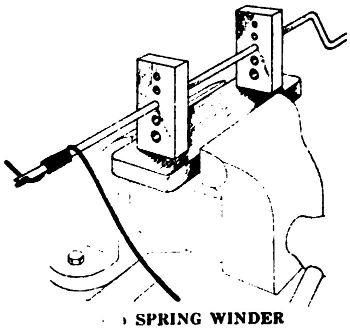
VALVE-CAP WRENCH

A wrench for removing slotted-head valve caps may be made from a bar of steel 2 in. round and 6 in. long. A ¾-in. hole is drilled through the center of the piece and the jaws filed on the lower end, as shown. A transverse hole drilled in the upper end permits the insertion of a bar ½-in. round for a handle. The threads of the cap should be smeared with a paste made of graphite and oil before replacing the cap.—Hudson



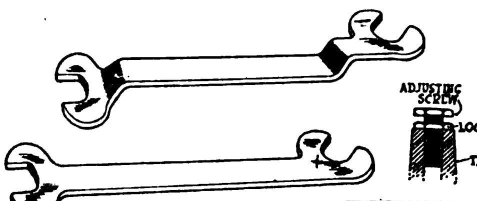
DRILLING CLUTCH YOKES

It is usually necessary to remove the clutch yoke when drilling and tapping it for an oil-cup attachment. By the aid of the drilling fixture shown this may be done with all parts in place. A 5/16-in. square steel rod is drilled and tapped ⅜ in. on one end and the drill fastened in the other end by brazing. The drill is rotated by the ratchet wrench and fed into the work by the set-screw braced against the flywheel. The length may be made as little or as much as is necessary, and a similar drill may be made for drilling almost any inaccessible hole.—



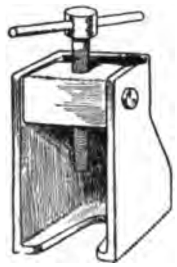
SPRING WINDER

Springs of various sizes may be wound on the spring winding outfit illustrated. A cast-iron frame supports two uprights that act as bearings for the spring winding spindle. These spindles are tool steel rod, having a diameter somewhat smaller than the inside diameter of the spring to be wound. One end is bent to form a crank and handle, the other being notched to receive the spring wire.



VALVE TAPPET ADJUSTMENT

The valve tappets of the Maxwell may be readily adjusted by means of special wrenches provided for that purpose. Two standard 626-X check nut wrenches are purchased at any supply store, and bent, after heating, in the manner shown. After loosening the lock-nut the adjusting screw may be turned until a gage registers the proper clearance. This should be from .006 to .009 in.—

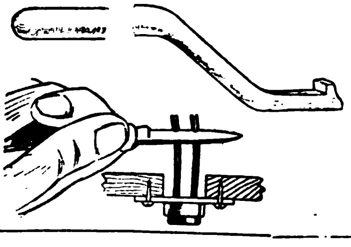


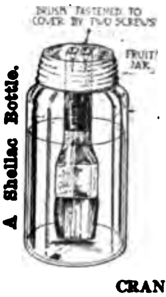
GENERATOR GEAR PULLER

A puller for removing the generator gear on the Dodge car is shown. The housing is made of cast iron, cut away at the base to engage the gear and provided with a ¾-in. set-screw for obtaining a leverage on the generator shaft. The feature of the puller is the method of attaching the set-screw to the housing. It is screwed through a swiveled cross-member, thus permitting it to be swung out of the way when being placed on the gear.—

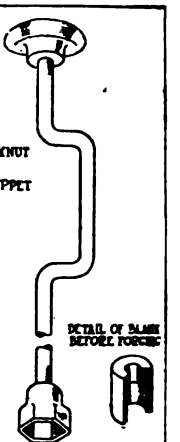
GENERATOR SPANNER WRENCH

A spanner wrench for facilitating the adjustment of the silent chain drive on the motor generator of the Dodge car. It consists of a piece of ½-in. round stock about 9 in. long, bent and formed in the manner shown. To adjust the chain, the chain-inspection plates are first removed from the motor gear cover Then the set-screw on the cylinder casting and the strap holding the motor to the hand hole cover plate are loosened. By means of the spanner wrench the eccentric bushing is turned until the chain has the proper tension. When properly adjusted the chain should run without perceptible noise.—



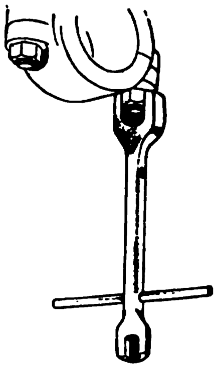

BRUSH FASTENED TO COVER BY TWO SCREWS
FRUIT JAR

A Shellac Bottle.



CRANKCASE WRENCH

The retaining nuts on the crankcase may be quickly removed or replaced by the aid of this wrench. The handle is made of ½-in. round stock bent in the form of a bit-stock, as shown. The upper end is fitted with a hand rest; the lower end with a socket for engaging the nut. A short piece of round stock, slightly larger in diameter than the nut to eventually be turned, is drilled, as illustrated in the smaller sketch. It is then heated and formed over the nut it is to fit, case-hardened and secured to the handle by a pin.—



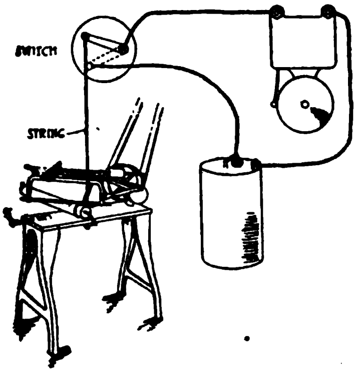
CRANKSHAFT BEARING WRENCH

It is often difficult to get a socket wrench thin enough to fit between the nut and the bearing housing of the connecting-rod or crankshaft bearing. Or if thin enough to do this the wrench is too weak to properly tighten the nut. A solid S-wrench may be used, but is not as satisfactory as the socket for this purpose. A solid socket wrench, cut away in the manner illustrated, possesses the required strength and has all the advantages of the full-socket wrench. As the connecting-rod nuts are not the same size as the main bearing nuts, the wrench should be made double-ended and fitted with a removable handle.—

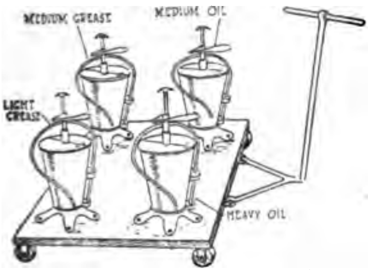
KNIFE FOR SWITCH TEST

To test a switch in order to ascertain whether it is short-circuited or whether one or both of the wires have become detached, press a knife blade through the insulation of both wires leading to the switch. This will not harm the insulation enough to cause trouble.—

HART NO. 302—Miscellaneous Repair Shop Hints. (Motor World.)
harts 301 and 303 omitted (error in numbering).



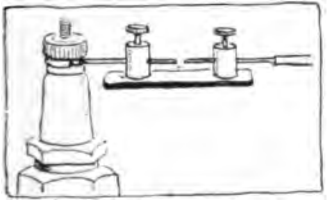
Not all hacksaws are equipped with a device to automatically shut off the power when the piece has been sawed through, consequently it is desirable to have some sort of an alarm to call attention to the fact that the cutting is finished. An electric battery and bell with a simple switch in circuit are the units required for such a signal. The switch lever is tied to the piece which is being cut by a string of whatever length required, the result being that the instant the piece is severed it drops and closes the switch and the bell rings.—



A handy truck for handling oils and grease either in the service station or garage may be made by building a small wooden truck mounted on castors and placing on it small tanks equipped with self-measuring pumps. In the device shown the Weaver bucket pump is used. The self-measuring feature enables the oil and grease to be sold at the curb or in the garage in the same way that gasoline would be from a wheel cart.—

Ignition Tester

To find which cylinder is missing, a piece of fiber ¾ in. long, about ⅛ in. thick and ¾-in. wide is taken, and near the ends are inserted cable terminal posts Through each post is passed a copper wire, the ends at the center being adjustable through lateral movement of the wires. One of the wires has a loop at the end for attachment to a plug. The ignition cable is attached to the other post. With one of these on each plug and the wires at a varying gap, it is possible, especially in a dim light or darkness, to see the action of the plugs.



Spark gap for finding ignit.on trouble

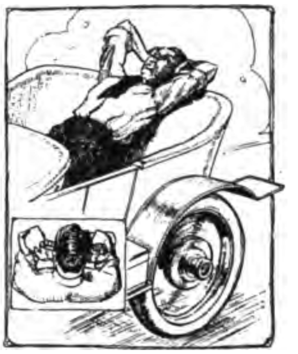
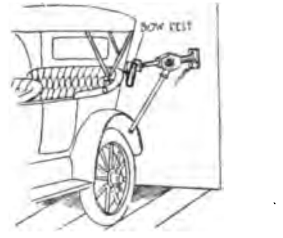


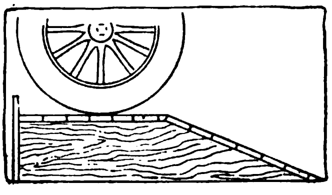
Fig. 1—Listening for rear axle hums; the hands are placed in front of the ears to intercept the sounds

Various Axle Hums Defined

The adjustment of axle gears can best be determined by sitting in the rear seat and holding the hands over the ears (Fig. 1). Should the sound from the axle be a steady hum and not too loud the gears may safely be said to be adjusted properly. If, however, there is an occasional stress in the sound, that is, a steady hum interrupted with a rather loud note, the adjustment may be incorrect. It will be found in testing in this manner that the gears may sound well when the car is running at uniform speed, slow or fast, but that as soon as a pick-up is desired a stress in the sound will be heard. Then again the gears may sound well except when coasting, which is another ailment which may be corrected by adjustment. If after trying various adjustments, perhaps taking in the whole range, the gears still give a characteristic loud note at intervals, it may be that one or more teeth are broken or the gears are slightly out-of-round.



Many times an ordinary jack may be used to advantage in straightening bent parts. For example, one of the rests for the top bows was bent in a slight accident and it was quickly straightened by backing the car up close to the garage wall, as shown, and using a jack.—

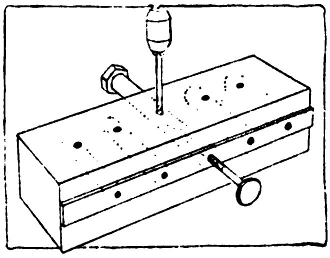


Box Substitute for a Pit.

While not new, the substitute for a pit illustrated is worth describing because of its merit. Two heavy wooden boxes, one for each wheel, with a slope of about 30 degrees, and a flat space on top are used. The boxes are constructed of 1½- or 2-inch planks; the height is about 10 inches and the length about 4 feet. Such boxes will support even a heavy car.

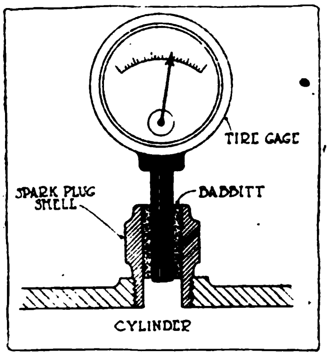
Jig for Cotter Holes.

A jig for drilling cotter pin holes in bolts and pins may be made of a piece of square stock in which there are several transverse holes for receiving various sizes of pins. At right angles to each one of these is a hole through which the cotter pin drill is inserted. The distance that the cotter hole is from the end of the pin is determined by the adjustment of a stop screw which is carried in a plate in the back.



Compression Tester.

A compression tester is necessary for accurately determining the condition of valves and pistons as regards their tightness. A cheap but satisfactory one may be made by combining a tire gauge and a spark plug shell. The gauge may be fastened to the shell by pouring babbitt or lead in between the two or a special reducing nipple may be used. The gauge, of course, is placed in the spark plug hole when a cylinder is to be tested. A weak cylinder can be readily indicated even if the normal compression in pounds is not known, by the fact that it will register less than the others. The use of this device is very important; it should be employed whenever any irregularity is noted in the operation of the motor. Leaky valves, pistons and valve stem guides may cause a miss or a jerky action that ordinarily would be blamed on the carbureter or ignition.



Compression tester made of tire gauge and spark plug shell

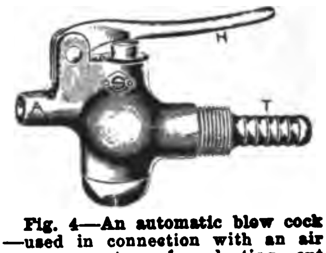


Fig. 4—An automatic blow cock —used in connection with an air storage system for dusting out cars, cleaning engine and parts. T—connects with air line. H—handle. A—blower opening. (Stevens Co., N. Y.)

CHART NO. 804—Miscellaneous Shop Hints.
Chart 803 omitted (error in numbering).

REPAIRMAN'S CHECK SHEET.

Make. .. .. Owner.. ... .
Body Type............... Address.................
Capacity..... .... Phone...... . ...

√ **Engine** $

Valves (grinding, etc.).
Timing gear (adjustment) ... .
Rod bearings..... .....
Main bearings ....
Pistons and rings.....
Oiling ....
Carbon (removal).....

Ignition

Wiring ....
Plugs ....
Coil ....
Magneto ....

Fuel System

Carburetor ....
Line and tank ....

Cooling System

Fan ....
Radiator ....
Pump ....

Starting—Lighting

Generator . ...
Starting motor........
Bulbs .. ..
Wiring ....
Storage batteries......

Clutch

Adjustment . ...
Relining . ...

Transmission

Gears ....
Bearings ....
Shafts ....
Shifting mechanism...
Driveshaft ....
Universals ....

Rear Axle

Adjustment ....
Gears ....
Bearings ... .
Radius rods ....
Torque member ......

Motor World Systems

√ **Front Axle** $

Alignment ....

Steering Gear

Adjustment ....
Bearings ....
Gears ....

Running Gear

Springs ....
Brakes ....
Wheels ....
Fenders ....
Runningboards ....

Tires

Front . ...
Rear ....
Extra ....

Body

Paint ....
Upholstery ....
Floorboards ....
Windshield ....

Equipment

Speedometer ....
Top and curtains.....
Horn ....
Tools ....

Extra Equipment

....
....
....
....
....
....
....
....

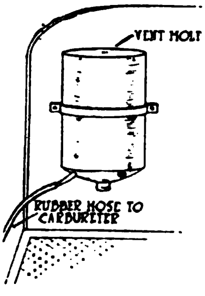
Overhaul Cost

....
....

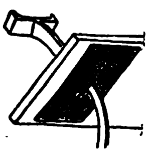
Appraiser

When quoting prices on repair work it is advisable to keep a statement of work necessary, marking after each item the cost. Keep original with owner's signature and give copy to him.

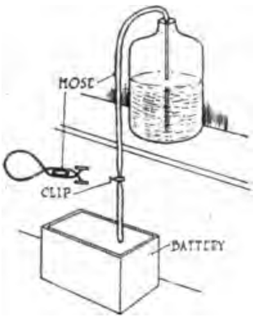
Extra equipment: include here the tools left in his car, then there can be no dispute. Put them in stock room. This plan can be elaborated upon—see also page 600.



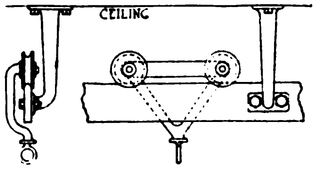
It is often desirable to determine the exact consumption of a given car by determining how far it will run on a measured quantity of fuel. A convenient means of doing this is to take an ordinary ½-gal. kerosene oil can and place in it a quart of gasoline. A rubber tube running to the carbureter is then attached to the spout and the can is inverted and tied securely at some convenient place on the motor or dashboard.



A cold draft preventive—a piece of sheet rubber placed as shown.

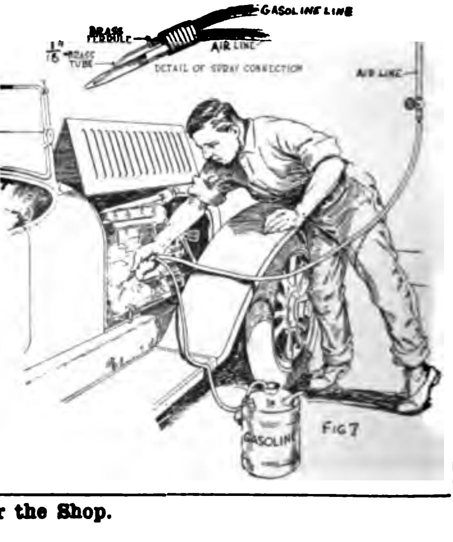


The principle of the syphon may be used in many places in repairshop work. For example, it provides a simple method of drawing distilled water for the storage batteries. A glass tube extending to the bottom of the bottle is inserted in the cork and a rubber tube is attached as shown. The end of the glass tube must extend below the bottom of the bottle, consequently it is advisable to place it on a shelf. The tube may be made long enough to reach to the storage batteries. The flow of water is controlled by a simple spring device which pinches the tube. This may be made, or purchased at a drug store. To put the syphon in operation it is merely necessary to suck on the tube until it is filled with water. Once this is done the water will remain in the tube and the syphon will always be ready for instant operation until the bottle is emptied. The same principle may be applied for drawing gasoline from a tank, oil from a crankcase, electrolyte from a storage battery, and is adaptable to many other uses. Of course, it is usually more convenient to drain a gasoline tank or crankcase in the ordinary way, but sometimes the syphon principle will be found quicker.

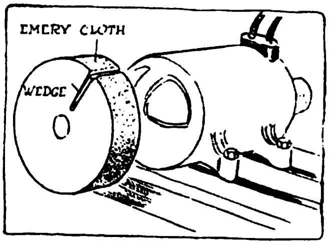


An overhead railway for repairshop use may be patterned after those in use in large butcher shops. It consists of a track made out of stock about ½ x 2 in. and suspended from the ceiling by arms at frequent intervals. On this track is placed a cap, to which the block and tackle is attached.—

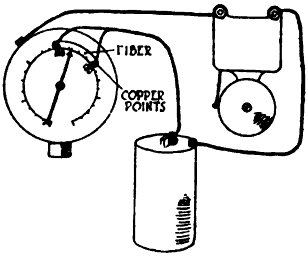
Fig. 7—Another engine cleaner: Parts may be readily cleaned by a gasoline spray or aspirator, actuated from the air pressure line. This spray comprises a short length of copper tubing, about ¼ inch in diameter, having a piece of 1/16 inch brass tubing soldered onto its side. The air line is connected to the larger tube, and the smaller tube is connected to the gasoline supply. When the air is turned on, a suction is created in the smaller tube, drawing gasoline from the can, and forcing it onto the part to be cleaned. (see also fig. 5, page 744.)



A grinding wheel for doing special work can be made by attaching a wooden wheel to the electric drill and wrap-



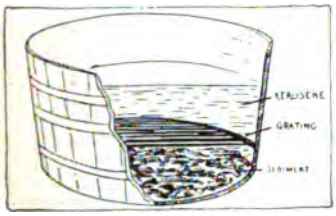
ping a strip of emery paper around the periphery. The paper is fastened by cutting a notch in the wheel and holding the ends of the paper by driving a wedge into the notch.



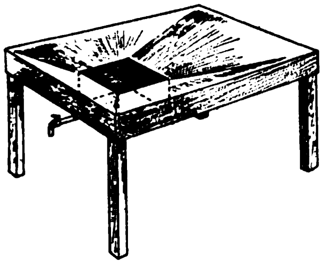
It is a very simple matter to build a device which will cause a bell to ring when the pressure in the air tank reaches the desired maximum or minimum, thus reminding the man in charge that the compressor should be turned off or on. The indicating hand on the air gage completes a circuit by touching a metal pin when it moves to either extreme, and thus makes the bell ring. These pins are mounted in a small fiber block, which is riveted to the face of the gage. The two pins are thus completely insulated from the gage and are connected to one terminal of the bell. A short piece of wire runs from the other terminal to the battery and the return wire is attached to the casing of the gage, so that current flows through the casing and the hand to one or the other of these metal points.

Kerosene Tub

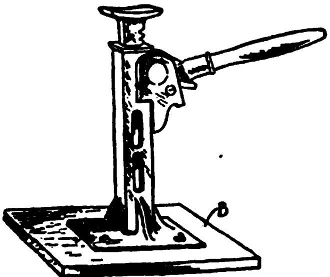
A large tub of kerosene will be found convenient for washing parts. The tub should have a metal grating 4 or 5 in. from the bottom, so that whatever sediment settles is not stirred up each time a part is washed. The presence of the grating insures clean liquid for a considerable length of time, for just as soon as a part is washed the grit and dirt settles below the grating, leaving the liquid clean.



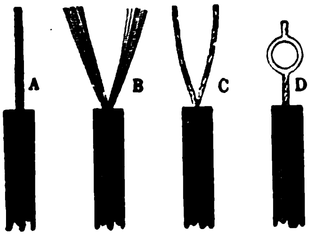
Kerosene tub with metal grating



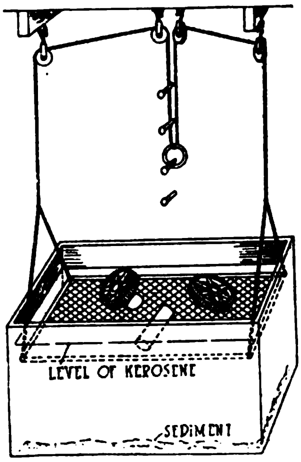
A roughly made table, covered with tin or zinc and with a well in it for holding kerosene, makes a handy arrangement for cleaning parts. There is a drain at the bottom for removing the sediment.



A flat block should be placed under a jack when used around a car to prevent turning over and sinking in the ground.



Four steps in making loop end: A, insulation removed; B, separating the strands; C, twisting wires into two leads; and, D, the looped end dipped in solder. (Motor Age.)



Combination cleaning tub and drainboard for removing the dirt from parts. It is usual to make the tubs and drainboard separate, but by installing a screen in the tank whose height may be readily raised or lowered, all the advantages of drainboard are obtained, together with considerable economy of space and some added conveniences.

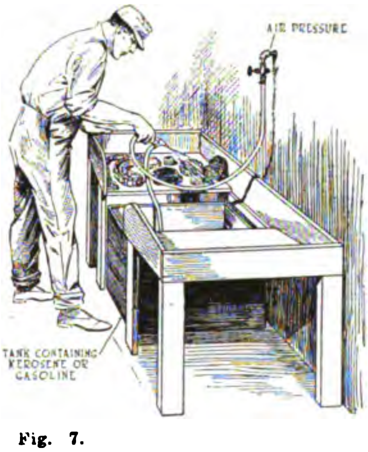
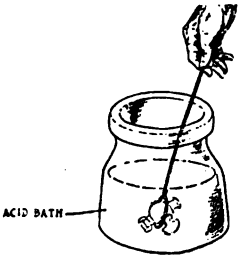

AIR PRESSURE
TANK CONTAINING KEROSENE OR GASOLINE

Fig. 7.

Fig. 9—To assist in removing heavy truck wheels a simple skid can be made by placing a 2-in. board on top of a series of rollers made of old shafting or heavy pipe. Chocks are fastened to the board to prevent the wheel rolling.

Fig. 10—This is the "ball and spring" oil regulator, as explained on page 198. Note how the adjusting screw increases tension on spring through the part (C). Dirt beneath this ball (B) check valve will cause a drop in pressure, and may be removed by snapping the ball (B) up and down a few times with a piece of wire (W) inserted through the oil passage.

Fig. 16—To remove wheels from a truck axle when stuck or rusted on.



Cleaning Brass Parts.

Small brass parts, such as pet cocks, carburetor parts, etc., may be made to look like new by dipping them in the following bath; Nitric acid, 75 parts; sulphuric acid, 100 parts; lampblack, 2 parts, and salt, 1 part. This solution should be mixed and kept in an earthenware or glass jar, and the parts should be thoroughly rinsed and dried after dipping—(see also pages 401 and 508.)

No. 7—Gasoline, or kerosene, forced by air pressure onto the parts to be cleaned, quickly removes all dirt and grease. A system for doing this is illustrated. The cleaning liquid is held in a metal tank placed beneath the inclined cleaning troughs in the manner shown. An injector type nozzle, connected to the air line and to the liquid, permits the liquid to be drawn from the tank and forced onto the part to be cleaned, after which it drains back to the tank to be used over and over again. During the periods that the cleaning outfit is not in use the dirt settles to the bottom and may be scraped out—see also fig. 7, page 740.

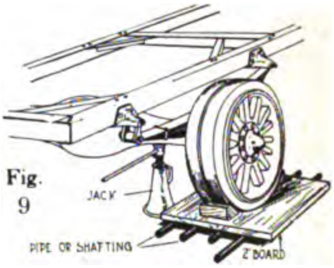


Fig. 9

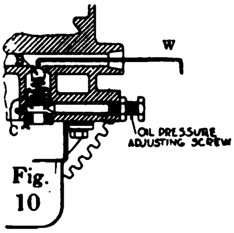
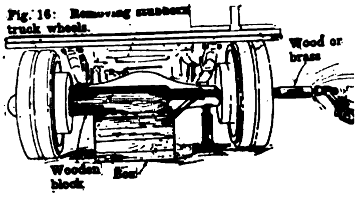


Fig. 10

Fig. 16: Removing stubborn truck wheels.



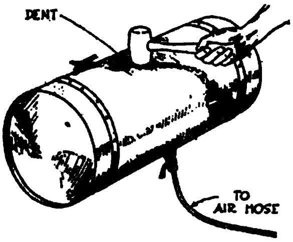


Fig. 17—A dent can be removed from a gasoline tank by plugging vent, filling with water and applying 20 lb. air pressure. A lead or wood mallet is used by tapping gently around outer edge of dent.

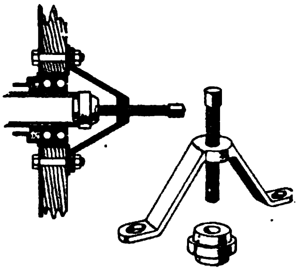
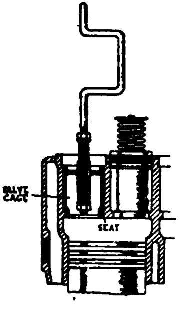


Fig. 2—Rear wheel puller: This puller is used to remove the rear wheels of the **Buick**. The wheel flange and axle are removed and the puller bolted to the flange bolts. A steel button is then placed in the rear axle tube, and the pressure applied by the central screw. By having several sizes of steel buttons, and making the flange bolt holes oval, this puller may be used on many cars.

Fig. 3—Valve cage grinding on the Buick may be quickly ground to a seat by the aid of this tool. It is ¼ in. steel rod bent in the form of a bit brace, and threaded at the lower end. The valve cage to be ground is caught between two nuts on the threaded end, and the cage is ground to a seat the same as valve. (see also page 688.)



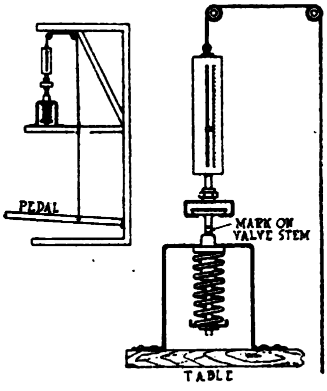
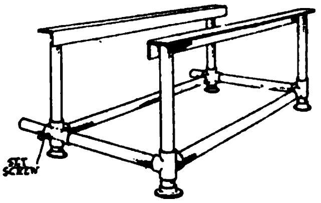
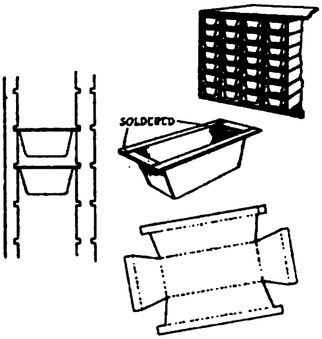


Fig. 2—When engine is overhauled, the old valve springs should be tested to see that they have not weakened, and whenever a new spring is put in, it should also be tested to see that it supplies the correct pressure. The illustration shows a simple means of determining whether a spring is in good condition or not. The apparatus consists of a bracket in which is mounted a valve guide, valve, spring, spring seat and retaining key. Two marks are placed on the valve stem, one indicating when the compression of the spring is zero, and the other when it has been compressed a certain amount, say ⅛ inch. The number of pounds required to compress the spring ⅛ inch may be ascertained by writing to the factory. When everything is in place, the pedal is depressed and the valve is raised until the lower mark on the stem is on a level with the top of the valve guide, at which time the pull as registered by the spring scales should be the amount called for by the factory.



Except for the two angle irons, which carry the motor arms, this stand is made entirely of pipe fittings. The left member may be slid to the right or left to provide for motors of different widths This is possible because the horizontal openings in the cross-shaped pipe fittings are large enough to take the cross pipe. Set screws are used to lock the stand after it has been adjusted to the desired width.



Small parts, such as screws, bolts, washers, nuts, gaskets and the like, are conveniently kept in tin drawers, as illustrated. The drawers are cut from a single piece of tin and are soldered, as shown by the heavy lines. The drawers slide in grooves cut in planks placed vertically. The grooves are made with a saw and chisel. The advantage of this method of storing parts is that the construction of the receptacles is very inexpensive and maximum convenience is afforded. It is possible to see what is in the various drawers without pulling them out, which is a feature peculiar to this design and saves considerable time when the exact drawer a certain part is in is not known.

Speedometer Pointers.

When speedometer pointers vibrate—look for loose unions, connection, flexible shaft bent too sharp, lack of lubrication, gears not properly meshing.

Failure to indicate speed—look for same causes as above. Also for broken link in shaft.

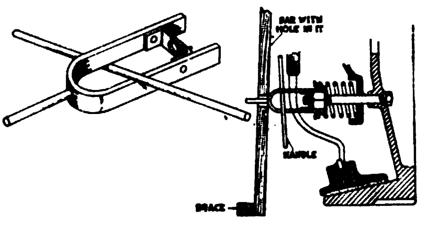
Noisy; lack of lubrication or above causes. (see also page 513.)

To Put a Lamp Reflector in Condition.

When reflector becomes dull it may be polished or buffed. If plating is thin and will not stand buffing—the old plating must be removed and re-plated and polished by an electro plater. If a good heavy plating is put on, it can be rejuvenated and be practically new again.

Buick Spring Compressor.

Fig. 4. Combined wrench and spring compressor: Though designed primarily for replacing the clutch bolt on the Buick D-28, this tool may be adapted to almost any job that requires a spring to be compressed before the nut is replaced. The wrench proper is a U-shaped piece of steel, bent to just fit the face of the nut, and held together by a cross strap. A rod, placed in the manner shown, permits a wooden lever to be used to compress the spring, after which a steel bar, stuck through the legs of the U is used to screw the nut in place.



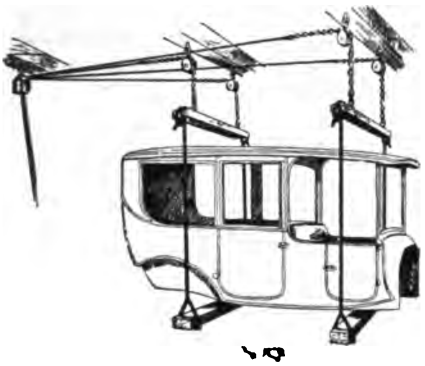


Fig. 1—Closed bodies may be removed without strain by the aid of the hoisting cradle illustrated. Two cross pieces are attached to separate chain hoists and are so spaced that they hang 2 ft. from the ends of the body to be removed. First one end of tho body is pried up, and a lower cross-member slipped beneath it. Then the other end is raised, and the other lower member put in place. The steel stirrups are then used to attach the lower and upper cross pieces, after, which the body may be raised and the chassis rolled from under.

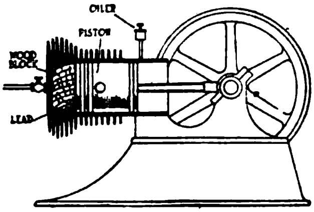


Fig. 6—A serviceable *air-compressor was made out of an old one-cylinder, air cooled stationary engine with very little work. In order to raise the compression pressure it was necessary to minimize the clearance between cylinder head and piston. This was done first by fitting a conical wooden block to the piston head and holding it in place with three ¼-in. cap screws. Then the space surrounding it was filled with lead. The intake valve of the engine is still the intake valve and the discharge valve is a ball check valve operating on a hard rubber seat in the discharge pipe, as close to the cylinder as possible. The exhaust valve opening was plugged up and all excess fittings were removed from the engine. The piston was fitted with step rings and a force feed oiler was substituted for a drip type. The compressor will fill a 16x48-in. tank to 158 lb. in 25 min. with a 1-hp. engine. The bore and stroke are 3½x3⅝ and the speed is 225 r.p.m. (Motor World.)

Fig. 5

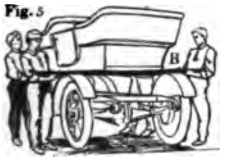


Fig. 5 — Removing a body: Showing how the body of a car can be easily lifted from or onto the chassis, and conveniently transported about the garage or shop.

Fig. 7

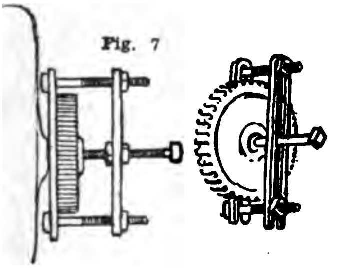
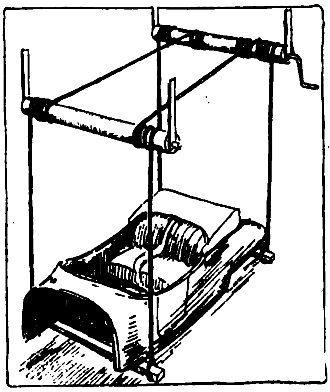


Fig. 7 — A gear puller for removing tight gear wheels. The illustration explains its construction and action. (also see page 606)



Turning one crank lifts all four corners of the car body at the same time

Fig. 2 — Another hoist for raising a body in the minimum time is illustrated. The body is supported by the hoist until the overhauling is completed, when the chassis is rolled back under and the body lowered in place again. The hoist consists of two 4-in. metal rollers about 5 feet long, one for raising the front of the body and the other the rear. These are suitably supported in a wood frame and are placed about 10 feet apart. The hoisting is done by a large crank attached to one of the rollers. All four ropes are wound around this sheave, and two of them run to the other sheave which is merely used as an idler. Seven-eights hemp rope is used. The body may be attached to the ropes by either fitting hooks to the rope ends or looping the ends of the ropes and using two cross bars under the body, as illustrated.

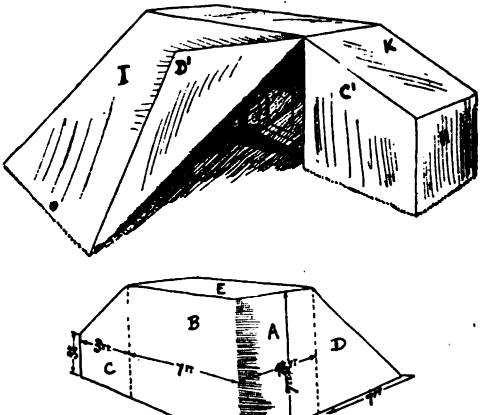


Fig. 8—A servicable tent for touring: Although this subject was fully treated on page 516, this being such a servicable outfit it is mentioned here as a timely suggestion, although out of place in this chart.

Use 8 oz. duck which comes in 36-inch widths and can be purchased at 20c per yard.

Dimensions of tent in square feet: A—4½'x 7'=31½'; B—7' x 7'=49'; C—3'x5¼'=15¾'; C1—3'x5¼'=15¾'; D—7'x7'=49'; D1—7'x 7'=49'; E—4½'x7'=31½"; H—4½'x3½'=15-¾'; I—7'x8'=56'; K—4½' x 4½'=20¼'; Total 284½' sq. feet or approximately 31¾ yds. at 20c per yard making $6.35. (Motor Age..)

See page 541 explaining symbols of feet (') and inches ('').

How To Run a Lathe.

"First Year Lathe Work" and "How to Run a Lathe"—price 10c each—supplied to readers of this book by the South Bend Lathe Works, South Bend, Indiana.

CHART NO. 308—Miscellaneous Repair Shop Hints.

*A motorcycle engine can also be utilized for a compressor.

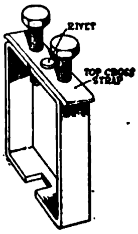


Fig. 1.

Fig. 1—This is a simple tool for compressing the clutch springs on the Reo when assembling the clutch. It is a strip of flat iron, bent into a square, and riveted together by a cross strip as shown. Holes are drilled and tapped at each side of the cross piece for the pressure screws. In addition to holding the ends of the top together, the cross strip also furnishes sufficient material to give the pressure screws a good purchase. The lower cross strip should be notched in the manner illustrated.

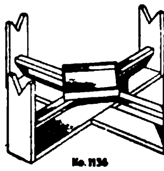


Fig. 3.

Fig. 3—Though designed for work on the Ford rear axle, this stand could readily be adapted to the requirements of many makes of axles. The ends of the axle are supported on notched uprights, about 30 in. from the floor and the torque tube is placed on either of two uprights similarly notched.

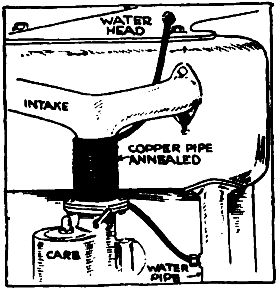


FIG. 2—HOT WATER JACKET FOR MANIFOLD

Fig. 2—Method of heating a long inlet pipe. Annealed soft copper pipe, small size is connected with discharge pipe from water pump, wrapped around manifold and connected with head.

Heating the Mixture on Old Carburetors.

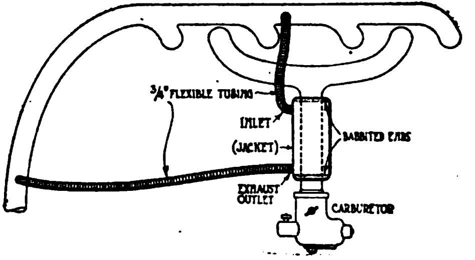


Fig. 10—Improving old type carburetors which were designed for gasoline of higher vaporizing qualities and long inlet pies.

Many of the old model carburetors do not work well on the present low grade gasoline. If too ancient, it is best to get a new model, but where in good condition the older models can be improved by adding a hot air jacket as shown in fig. 10.

Use a pipe of some kind and slip over the intake manifold—about ¾ of its length. Weld gas tight at each end (sheet iron can be made into a pipe) and pour light layer of babbitt in each end to close up any holes or cracks.

A ⅜, ½ or ¾ inch (larger the better) flexible pipe is then attached to top and bottom of jacket to exhaust pipe as shown, or lower pipe can extend to lower part of engine—see page 157.

Fig. 11—Another method of heating the carburetor mixture on old cars that have a long inlet manifold. A ⅜ or ½ inch copper pipe is tapped to the exhaust manifold and run down along the intake manifold, being held away from the latter slightly by asbestos pads. Asbestos is then wrapped around the manifold and pipe and the heat thus obtained will help to prevent the gases from condensing in the manifold at the point where it branches out to the cylinders.

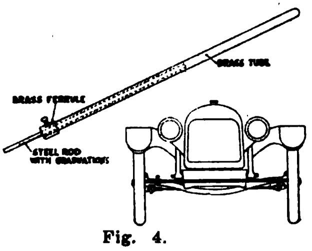


Fig. 4.

Fig. 4—The brace rod from an old windshield may be made into an excellent wheel alignment tram. After cutting the rod to a length about 2 in. less than the distance between the front wheels, a brass ferrule is soldered to one end. This ferrule is then drilled and tapped to carry a thumb screw in the manner shown. The adjustable part of the tram is a piece of ¼ in. drill rod, marked off into 1/16 in. divisions as shown, and placed within the tube.

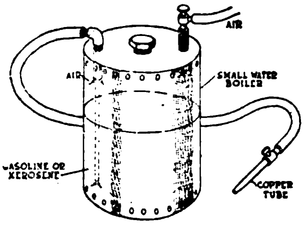


Fig. 5.

Fig. 5—This is a cleaning tank, in which gasoline or kerosene is forced by air pressure in a form of a spray onto the part to be cleaned. The container is an old hot water heater boiler. Air pressure is applied through a tire valve soldered to the tank, and the cleaning solution is drawn up through a small tube to the outlet pipe. A length of rubber hose, terminating in a copper tube, fitted with a valve, completes the outfit. Either gasoline or kerosene may be used as a cleaning solution, but the latter is preferable.

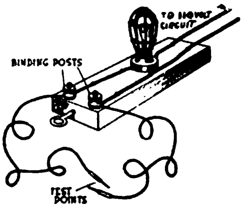


Fig. 6.

Fig. 6—This is a portable test lamp, used in conjunction with a 110-volt lighting circuit, for testing lighting and ignition circuits on the car. It consists of a wooden base, on which is mounted a porcelain socket carrying a 16-candle power lamp, connected to the lighting circuit as shown in the wiring diagram. The test points are connected to the binding post, and any metallic connection between the two causes the lamp to light. Hence if a wire is O. K., the lamp will light, when the test points are placed on each end of the wire. If there is an open circuit, it will not light. Similarly short circuits and grounds may be determined. By short circuiting the two binding posts, the lamp may be used for inspection work.

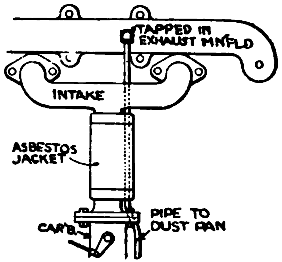


Fig. 11.

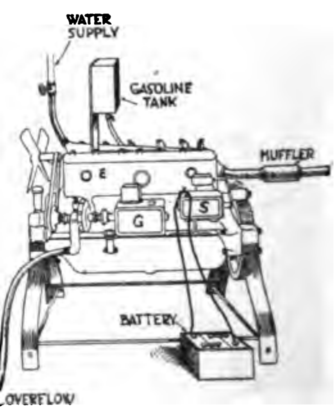


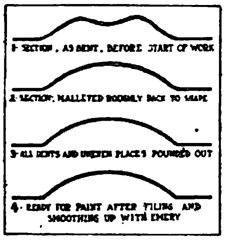
Fig. 12—An engine testing stand.

By supporting the engine on a cast-iron stand, and operating it from an auxiliary gasoline tank, storage battery, water supply, etc., the performance of the engine may be observed and the necessary adjustments made without difficulty.

: NO. 308-A—Miscellaneous Shop Hints.

World.)

Metal Straightening.


1- SECTION, AS BENT, BEFORE START OF WORK
2- SECTION, MALLETED ROUGHLY BACK TO SHAPE
3- ALL DENTS AND UNEVEN PLACES POUNDED OUT
4- READY FOR PAINT AFTER FILING AND SMOOTHING UP WITH EMERY

The four steps in removing a dent from a sheet of metal

There is but one secret to sheet metal straightening; to support all parts except that which is to be straightened, and to go slow, working the metal back to its original form by light blows.

To do this requires many special tools, some of them taken directly from the tinsmith trade, others can be developed on the job.

The Tools.

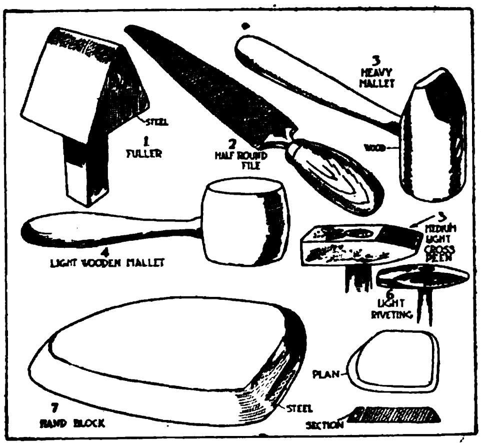
1–**The Blacksmith's fuller.**—This is used as a hand anvil, either in conjunction with the light mallet, or the light hammer, particularly to remove small dents. The combination of flat surfaces with the rounded edge will cover a wide variety of work.

2–**Half round file.**—After all dents or indentations have been removed by use of the mallets, hammers and hand anvils, this file is used to remove any small pits or hammer marks.

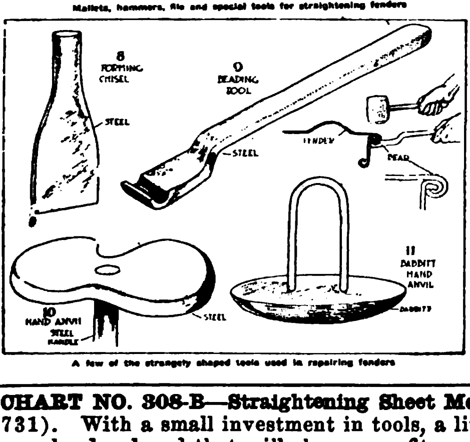
3–**Heavy wooden mallet.**—Used in the preliminary straightening to roughly form the metal back to shape. The flat wooden surface does not dent the metal on flat or crowned surfaces.

4–**Light wooden mallet.**—The most useful tool of all. After the metal has been pounded back to its original shape, the light mallet, in conjunction with some one of the hand anvils, is used to smooth up the work.

5–**Medium cross poen hammer.**—A tinsmith's hammer, used to still further smooth up the surface. Wooden mallets will not remove all of the smaller indentations. Hence this hammer must be used as it strikes the required concentrated blow over a limited area.



Mallets, hammers, file and special tools for straightening fenders



A few of the strangely shaped tools used in repairing fenders

6–**Light riveting hammer.**—Any minor indentation, not smoothed by No. 5 hammer, is taken out by the light riveting hammer. The cross poen is used to finish corners, prior to filing.

7–**Hand block.**—A steel block, roughly about 4 in. square, and 1 in. thick, with the corners rounded and beveled. The curves and beveled edges vary, so that some part of the block may be fitted to almost any part of the work. This and the light woden mallet are the most used combination.

8–**Forming chisel**—Made in an infinite variety of widths, shapes and sizes. The one shown is used to form sharp corners, or edges. One with a half-round edge is used to re-shape a groove. By grinding the edge to the desired form, the metal may be readily driven to that form.

9–**Beading tool**—The side strips on most fenders are held in place by rolled-in edges. When bent, these edges open. After straightening to the original form, the bead may be again closed by the aid of this tool, and a mallet or hammer.

10–**Hand anvil.**—An irregular shaped steel plate or block, mounted on a steel handle. The edges are beveled, and will fit almost any curved surface.

11–**Babbitt hand anvil.**—Made in an infinite variety of forms by pouring melted babbitt into an unbent portion of the part to be straightened. When hard, the shape is that to which it is desired to form the bent portion. Make handle as shown.

Reshaping Bent Metal.

It is not usually advisable to attempt to straighten mudguards and lamps having broken surfaces.

The first step is to work it roughly back to its original shape with a heavy wooden mallet. Care must be taken not to break the surface or to draw it beyond the original shape.

A hand anvil of some sort should **always be used in conjunction with the hammer or mallet to support the edges of the bent surface. Many light blows,** rather than few heavy blows, **should be applied,** and the blows should be drawn, **rather than applied dead on. The main thing is to go slow to feel the dents with the hand anvil, and to direct the straightening blow to the point of bend.**

After the surface has been malleted to approximately the original shape, the smaller dents should be removed, using first the small mallet and then one of the metal hammers. This is slow work.

Filing.

By passing the hand over the surface, many of the smaller dents may be felt and removed. Some, however, will still remain. These may be located by filing the surface down. The file will hit the high spots and pass over the low spots. **Then the low spots may be pounded up to shape.**

Finally it will be found that the file will touch all of the surface except the smallest indentations. Then file the whole surface down to a smooth surface and polish with emery paper.

The four steps in this work are shown on this page, the section being that of a crowned mudguard. But mudguard, lamp or body, the principle is absolutely the same.

Painting.

Before applying the paint, the surface must be thoroughly cleaned with turpentine. This removes all grease that would otherwise prevent the paint from sticking. If the surface is that of a mudguard the under side should also be cleaned and painted to prevent rusting.

For hurry-up jobs a quick drying enamel or a black japan may be used to paint the repaired section, the latter, of course, being only suitable for use on black guards or parts The japan, mixed in turpentine, will dry in about 15 min., and after a few washes cannot be detected from the rest of the finish.

Straightening Bodies.

Upholstery must be removed or the body raised to get at both sides of the surface. Another difficulty is that two men are often **required—one to hold the hand anvil and the other to use the mallet or hammer.** The co-operation between the two must be perfect or the anvil will not be back of the hammer blow and the surface will be still further bent. Body work is more difficult.

CHART NO. 308-B—Straightening Sheet Metal Parts. Tools Required and Methods—(see page 731). With a small investment in tools, a little practice and care in their use, a new department **may be developed that will show a profit, and also feed other departments.** (**Motor World.**)

See index for ''top-repairing.''

Truck Chassis; Chain and Worm Drive.

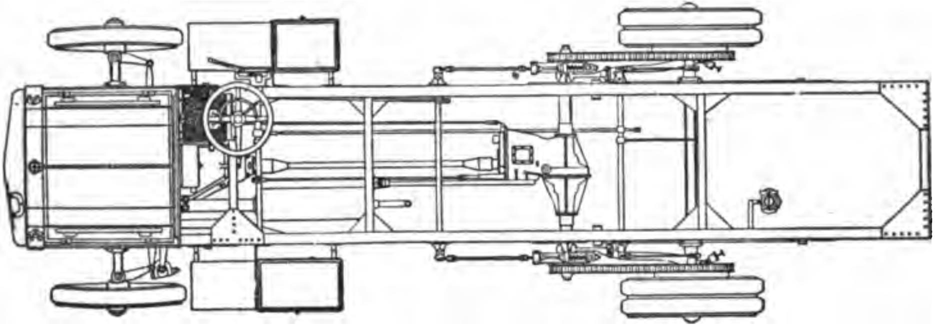


Fig. 1.

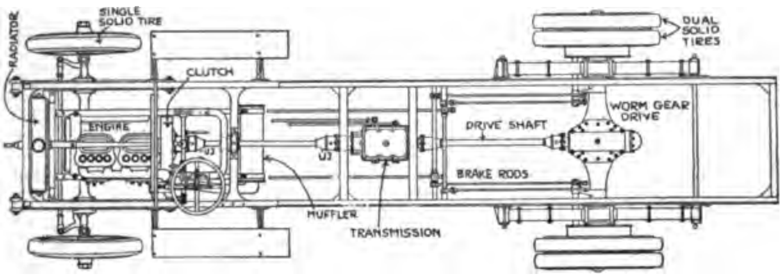
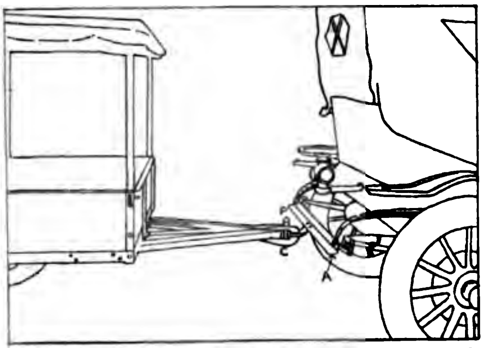


Fig. 2.

Fig. 1—Plan view of a double chain driven truck. The details of how this drive is arranged is explained on page 18. Four cylinder engine is employed

Fig. 2—A worm driven truck — four cylinder engine.



Type of two wheel trailer which can be coupled to rear of any automobile. Note one method of coupling at (O); angle iron (A) is attached to rear of car to which is riveted a coupling device.

*Trailers.

There are some industries in which a trailer is a particular boon to the consumer, namely, where the goods of relatively light weight and great bulk have to be carried. On the other hand, we find trailers equally efficient in the transportation of road material, etc. It cannot be argued that they are for any particular field of work, but rather that they are for all fields. Trailers, according to design, are divided into three divisions, as follows:

a—Four-wheel trailers.
b—Two-wheel trailers.
c—Semi-trailers.

The four-wheel trailer has a large possible field of utility and can be used in practically any service.

The two-wheel trailer has the load balanced on its axle.

The semi-trailer also uses two wheels but the load is not balanced over its axle, rather the front end of the load rests on the tractor vehicle, whether that be a separate tractor or a motor truck. This semi-trailer type is that design brought out by Knox, and is now manufactured by many other concerns.

Kissel Kar Truck with dump body and hoist.

Dump Body and Hoist.

A truck equipped with a dump body and hydraulic hoist. They are built for handling coal, coke, sand, gravel, etc., also for road building and construction work.

This body is made to fit on a hinge at the rear end of the chassis and the front end is raised by a hydraulic hoist which derives its power from the engine. The operator can unload the load in about thirty seconds by simply throwing a lever which turns the power into gear with the hoist. A similar movement returns the body to its horizontal position ready for loading.

HART NO. 809—Trucks; Chain and Worm Drive. **Trailers. Dump Body with Hydraulic Hoist.**

ee also page 822

INSTRUCTION No. 47.

COMMERCIAL CARS: Trucks; types and construction. Truck Chains, Worm Driven Rear Axles. Trailers. Fire Trucks.

The Automobile Truck.

It is interesting to note that the automobile truck and delivery wagon manufacturers have increased at a very rapid rate, greater in proportion than the passenger car.

Probably the subject of trucks will interest many of our readers as it is fast taking the place of horse drawn vehicles. There isn't much to be treated in this subject, however, as the truck as a whole, is precisely the same principle as the pleasure car—with the exception of minor details of construction which will be taken up in their respective order.

Therefore for one to master the truck construction and operation, he has but to refer to the subjects of **engines, carburetion, ignition, lubrication, operating a car, etc.**

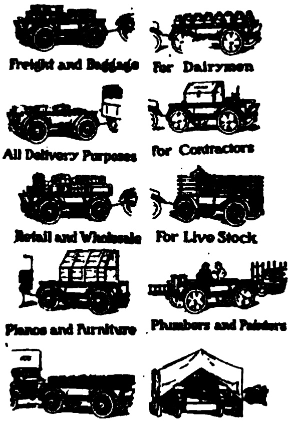
We will classify the commercial cars into two divisions; **motor delivery** and **trucks.**

The motor delivery is usually an automobile of the passenger car class, with a special delivery body, as illustrated on page 16. Inasmuch as this type of car was treated in previous Instructions, it will not be further dealt with here.

The truck is constructed along the same lines, except the chassis is heavier and chain or worm drive is usually employed.

Trucks are made in sizes from ½ ton capacity to 7 tons and over. The greatest number in use being the 1 to 2 ton capacity.

How to select a car for commercial use is treated on page 528.



Suggestions for the use of the trailer by the Northway Trailer Co., E. Rochester, N. Y.

The Motive Power.

Trucks are propelled by either gasoline engines or electric motors.

The electric type is dealt with on page 477. See also page 484.

Most of the trucks employ a four cylinder type of engine; some few use a double cylinder engine with the cylinders placed opposite, as per fig. 1, page 32.

*Engine.

The general principles of the engines are identically the same as used en pleasure cars; the ignition, carburetion, clutch and all parts except the drive principle is identically the same. Therefore, if the reader will master the above subject he will then understand the construction of a truck.

The Drive.

The double chain drive (see page 18) is employed on a great many trucks, this is due to the fact that a "dead" or solid rear axle can be used. (see page 20, fig. 1, for description of the transmission and jack shaft, and method for driving by double chains.)

The worm drive is coming into more general use. The rear axle construction using the worm gear is shown in charts 309A and 309B. The worm drive is usually adjusted at factory and seldom requires readjustment. Therefore it is well adapted for truck work where a "live" axle is used.

Details of Three Models.

Capacity lbs.	2,000	4,000	7,000
Price	$1,575	$2,200	$3,000
Wheelbase, in.	128	148	168
Tires, front	34x3	36x4	36x5
Tires, rear	34x4	36x6	40x5
Bore	3½	4⅛	4½
Stroke	5	5¼	5½
Horse power	19.61	27.20	32.40
Speed, r.p.m.	1,700	1,800	1,200
Speed, m.p.h.	22	17	14
Gear, ratio in high gear.	7¾-1	8⅓-1	10¼-1
Final drive	Worm	Worm	Worm

Gear ratio—Three speeds forward are usually provided, giving ratios in the gearbox of 4 to 1, 2 to 1 and 1 to 1; and with a rear axle ratio of 10⅓ to 1 the total reduction is 41⅓, 20⅔ and 10⅓ to 1. The face of the gears is on an average about 1½ inches wide.

Standard Demonstration Charges and Speeds for Commercial Motor Cars

Load Capacity Tons	Load Capacity Pounds	Speed M.P.H.	Demonstration Charges per day of 10 hours
½	1,000	16	$10.00
1	2,000	15	10.00
1½	3,000	14	11.50
2	4,000	13	13.00
2½	5,000		14.00
3	6,000	11	15.00
3½	7,000		16.00
4	8,000	10	17.00
4½	9,000		18.00
5	10,000	9	19.00
6	12,000		20.50
7	14,000		22.00
8	16,000		23.00
9	18,000		24.00
10	20,000		25.00

For truck information see index "Governors;" "Waukesha Truck Engine" and "Trucks." See page 678 for the "Internal Gear Drive Axle." See Eisemann magneto page 285 and "setting a magneto" page 312. This information and Instruction 34, 47 and page 561 ought to give one all the information desired to properly care for and operate a truck.

***See pages 333 to 338 for example of a typical truck engine and how to repair same.**

The Jeffery Quad Truck.

Now known as the Nash Quad differs from other trucks in that the 4 wheels are driven and steered. Manufacturers are Nash Motors Co., Kenosha, Wis.

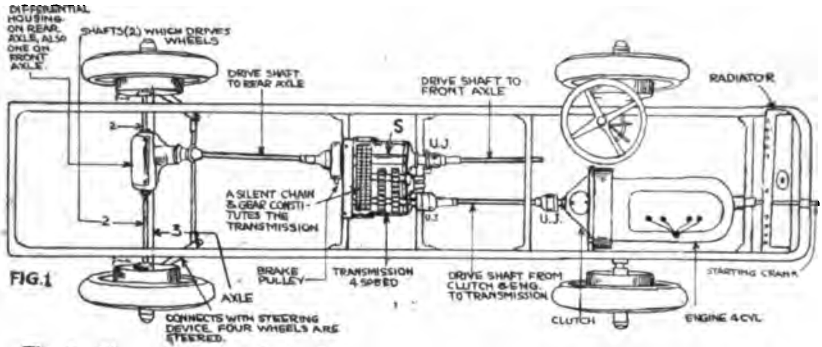

DIFFERENTIAL HOUSING ON REAR AXLE, ALSO ONE ON FRONT AXLE.
SHAFTS (2) WHICH DRIVES WHEELS
DRIVE SHAFT TO REAR AXLE
DRIVE SHAFT TO FRONT AXLE
RADIATOR
S
U.J.
2
2
3
A SILENT CHAIN & GEAR CONSTITUTES THE TRANSMISSION
U.J.
U.J.
FIG. 1
BRAKE PULLEY
TRANSMISSION 4 SPEED
DRIVE SHAFT FROM CLUTCH & ENG. TO TRANSMISSION
STARTING CRANK
AXLE
CONNECTS WITH STEERING DEVICE. FOUR WHEELS ARE STEERED.
CLUTCH
ENGINE 4 CYL.

Fig. 1—Shows top view of the Jeffery Quad, now known as the Nash Quad or 4 wheel drive and steered truck.

The method of driving the four wheels is as follows: The power is transmitted from clutch of engine (see fig. 1) to the 4 speed transmission, thence through a system of gears and silent chain to shaft (S). This shaft drives a shaft from universal joint (UJ) to a drive system on the rear axle.

Drive system on rear axle is shown in fig. 2. Note the differential housing is bolted to the axle (3) which is stationary or "dead."

Axle shafts (2) extend from each side and connect with a universal joint (B, fig. 3), by flange (F).

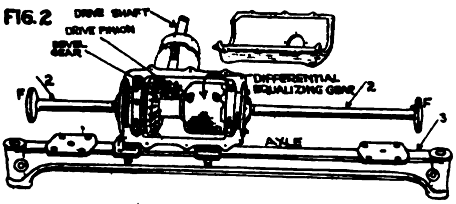


Fig. 2—Illustrates the method of placing the differential housing on the "dead" front and rear axle with drive shafts (2), which drive the universal joint (B, fig. 3) by flange connection (F).

Drive system in wheels is shown in fig. 3. The universal joint (B) is held stationary. The universal joint shaft (D) is fitted with a pinion gear (E) which drives an internal or driven gear (F) inside of wheel.

Although the illustration shows only one drive system on the axle, the same principle is used on the front as on the rear.

Steering is similar to other systems, except the rear wheels as well as the front are steered. By referring to fig. 3, the end of knuckle arm is shown. This connects with steering gear in a similar manner as other steering devices.

The feature to be noted is the universal joint (B, fig. 3), which allows the wheels to be moved at an angle, yet be driven. **Brakes**; there are 5—one internal expanding in each wheel drum, and one external contracting on drive shaft.

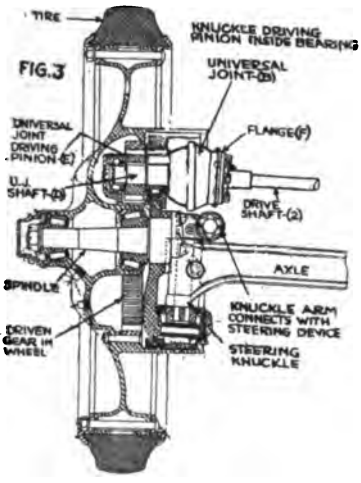


Fig. 3—One of the 4 wheels illustrating how the shaft (D) of universal joint (B), on which is a pinion (E) drives the internal gear (F) in wheel.

Steering is by connection in usual way of the knuckle arm with steering device.

Specifications.

The late model is known as model 4017. Engine is (Budda) 4 cylinder; L type cylinder 4¼x5½, 28.9 h. p.; **Ignition** is type "G4" Eisemann magneto, page 285; **Carburetor**—the model "L" Stromberg, see index; **Governor** is the Simplex, see index, this governor cuts off at a speed of 14 miles per hour or engine speed of 1500 revolutions; **Clutch** is the Borg and Beck, page 42; **Brakes** are internal expanding in each wheel; **Tires** solid rubber 36x5; **Wheel base** 142 and 124 inches; **Tread** 56 inches; capacity of truck is 4000 lbs., maximum is 5200 lbs; **Full tank** 26.7 gallons with reserve tank of 5 gallons; **Water capacity**, 11 gallons.

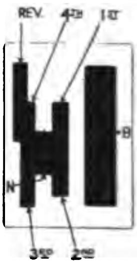


Fig. 4—The 4 speed gear shift:
1st speed.
2nd speed.
3rd speed.
4th speed.
Reverse.
N—neutral.

CHART NO. 309X—A Four Wheel Driven and Steered Truck; the Nash Quad formerly **known as** the Jeffery Quad.

other well known 4 wheel drive truck with "internal gear drive" is the Duplex Truck Co. Lansing, Mich. page 678 for an internal gear drive rear axle.

Operating a Truck.

It would be merely a repetition to go into details here as to operating a truck, because it is identically the same principle as explained in operating a pleasure car under instruction No. 34.

Usually 4 cylinder engines are used, see pages 833-838. Magneto ignition and governors are also used on truck engines—see index. Otherwise the operation and care is similar to any other automobile engine.

Truck Chains.

Baldwin roller chain "master link" with cotter pins and an extra roller link, for coupling.

Roller type chain: The truck chain is usually what is termed a roller type of chain. The roller part is clearly shown in the illustration. This is the part which fits in between the teeth of the sprocket.

1 ton truck; pitch 1"; di. roller 9/16 or ⅝"; width roller ⅝ to ¾".
2 ton truck; pitch 1¼"; di. roller ⅝ or ¾"; width roller ½ to ¾".
3 ton truck; pitch 1¾"; di. roller 1"; width roller ¾ to 1".
5 ton truck; pitch 2"; di. roller 1½"; width roller ⅞ to 1¼".

The pitch is measured from center to center of link, when roller type. The **width of roller** is measured along its length and the **diameter** is measured cross-wise, (or refers to its thickness).

To remove a chain the master link cotter pin or sometimes a wire clip is removed and the master link withdrawn.

On some chains the parts are detachable and the chain can be lengthened or shortened with ease, whereas with the solid chain the task is not so easy—a special tool must be used.

Care of Chains.

If chains could be protected from dust and be run in an oil bath, they would last much longer, but no method of doing this has yet been successfully devised. A case or housing cannot be fitted around the chain, because the construction would also require it to contain the brakes as well as the sprocket, and to surround the axle.

When chain becomes too slack the chain and sprocket are bound to suffer in consequence.

When chain is worn an uneven or jerking motion is imparted to the drive system when slowing down, coasting and suddenly picking up speed etc. Therefore a chain should be well lubricated and kept adjusted.

*Cleaning and Lubricating.

Tallow gives a chain the best protection against dust and grit. It is melted and chain (after being cleaned by soaking in kerosene) is laid in the liquid tallow—hang it up to dry and then wipe off the surplus grease.

Teeth of sprockets when worn may be remedied in some instances by reversing.

A new chain will stretch—a link should be removed after it is well set. The rivets are cut with a chisel. Master links should be carried.

Adjusting chain tension—slight play is necessary, but equal slack should be in each chain. They should be loose enough to run easy without climbing the sprocket tooth. Adjustment is usually made by the radius rod, or large adjusting screws provided for the purpose. (see page 20 showing radius rods equipped with right and left adjusting device).

The enlarged section in middle portion of radius rod is an enlongated nut, which is tapped with both right and left hand threads. The rods have threads cut on them to correspond. Turning the nut in one direction lengthens the rod and turning it in the opposite direction, shortens it. The principle is identically the same as in a turn buckle, this however is a much stronger construction.

Truck Tires. Rear Axle and Spring Lubrication.

Tires—several forms and types of solid tires used for truck service are shown in the tire instruction, see pages 560 and 561.

**Truck Rear Axles.

There is very little to be said about the chain driven rear axle as the wheels revolve on the spindle of the dead axle—usually on roller bearings. See page 31 for illustration of a dead axle and page 20 for a jack shaft. See also chart 309.

The worm driven rear axle is the popular type in use and as an example, the Sheldon is explained in charts 309-A and B.

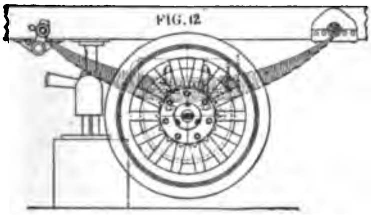


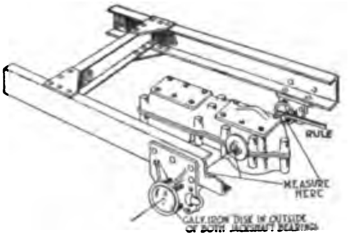
FIG. 12

Springs.

Springs—inasmuch as the springs of a truck are subjected to considerable strain, they should be kept in good condition. A method usually employed is to raise the frame of car with a jack as shown in fig. 12, which causes the leaves of spring to separate—graphite is then inserted between the leaves and wiped dry after removing the jacks. The spring clip nuts should be tightened occasionally.

A Truck Gear Box Alignment.

When replacing the gearbox on trucks having separate jackshaft brackets (as in the chain drive Mack), it is advisable to test the jackshaft and gearbox alignment. To do this, cut two disks of 1-64 in. galvanized iron to fit the outer bores of the jackshaft brackets, and drill a small hole through the center of each. These disks are placed in the outer bores of each bracket, and a fine thread passed through the drilled holes and the gearbox in the manner illustrated. Measurements from the outside of the bearings to the thread show when the alignment is perfect.



*See also page 741. See page 678 for the internal gear drive truck axle.

The gear shift of 3 and 4 speed trucks usually the S. A. E. standard, page 490. See page 560 for truck tires. See page 741; "how to remove a truck wheel."

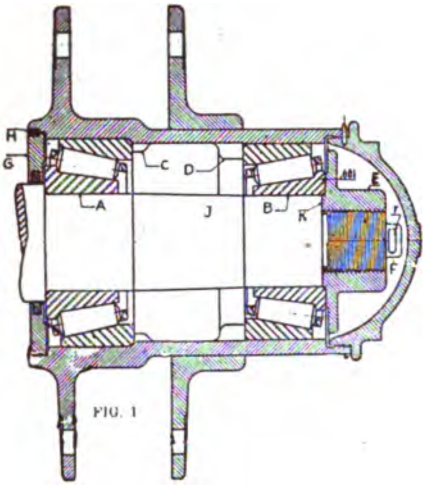


FIG. 1

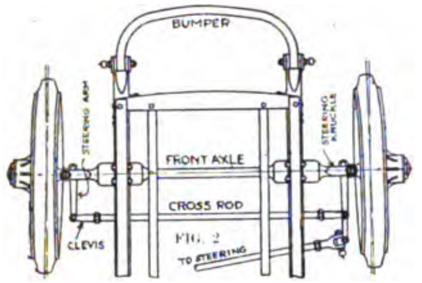


FIG. 2

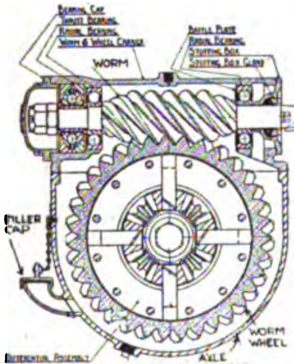


FIG. 3

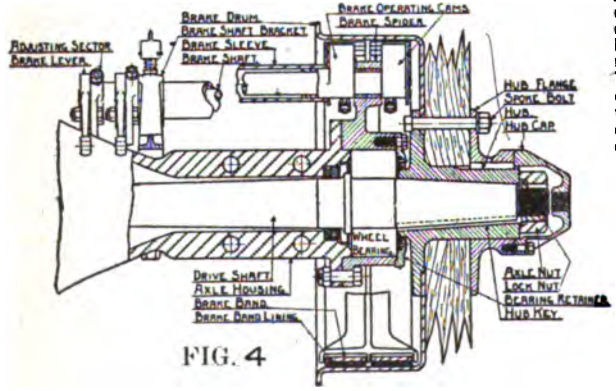


FIG. 4

Front Wheels.

Fig. 1—To mount front wheel bearings—taper roller: (1) insert bearing (A) in the hub and press against shoulder (C). (2) screw retainer (G) in place and lock with screw (H). (3) insert bearing (B) and press against shoulder (D). (4) mount hub on spindle (J) and tighten nut (E) against shoulder of axle (K). (5) there should not be more than 1-1000 inch clearance between nut (E) and bearing (B). To secure this fit, the hub should not be able to slide back and forth. There should be no endwise movement of spindle, but the bearings should not be bound and the hub should move freely. Shoulder on nut (E), could be filed down if hub does not fit freely. If wheel revolves freely you know adjustment is o. k. If not try another nut, having shoulder (K) more full.

Care must be taken that inner bearing seat is tight against the collar on the spindle. Test by moving wheel from side to side.

Fig. 2—Wheel alignment—To test; jack both front wheels up—with chalk held in fixed position against tires, spin wheels, drawing line around the tire. The distance between the lines measured at the front of the wheel should be from ⅜ to ½ inch less than in the rear.

To "take in" or "let out" on wheel alignment—Loosen clevis jam nuts on end of cross rod. Remove pins—screw clevis either in or out as needed. If steering knuckle is bent or steering arm is bent, replace it. If cross rod is bent—straighten before re-aligning wheels. Front wheels are "cambered" so wheels are little closer together at the bottom than at the top. See page 683 for "camber" and "toe-in."

Rear Axle.

Is of semi-floating type (see page 33.) Axle is mounted throughout on ball bearings except that straight roller bearings on the wheels are sometimes provided. Lubrication of the worm gears is very important. To put oil into housing—(see figs. 3 and 5)—unscrew filler cap and pour oil in until it overflows. When new it may be necessary to add oil every two or three weeks, if oil level goes down. Drain old oil every 5,000 miles and flush out with gasoline and thoroughly clean. Heavy oil such as 600W (steam cylinder oil) is best for worm gear lubrication.

Removing Rear Wheels.

To remove rear wheels, a wheel puller (fig. 6, chart 309-B) is provided. Jack up axle, unscrew cap screw (A), remove hub cap (B), remove drive shaft nut (C), press out disc (D), replace hub cap (B), insert set screw (E), and jam against drive shaft (F), tap back of wheel (G).

Do not attempt to pull wheel off by simply tightening up on the set screw. Be sure to tap against rim of wheel on inside, after you jam the set screw against the shaft, otherwise you are liable to strip the threads.

Replacing Rear Wheel.

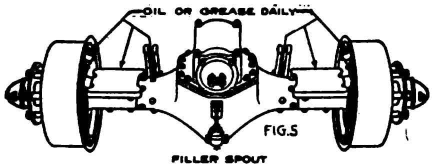
In replacing wheel on shaft, put key in position in key way, then place hub over shaft with key way in hub in line with key on axle shaft. You may not be able to get nut (which jams key) screwed in far enough at first, because the hub will not be far enough up on shaft. Do not attempt to draw the hub up with key jam nut alone, but drive wheel on and take up with the nut as hub creeps on the shaft. When hub is well up in position, take off outer nut, jam the key tight against the bearing with jam nut and then place outer nut back in position before putting on hub cap.

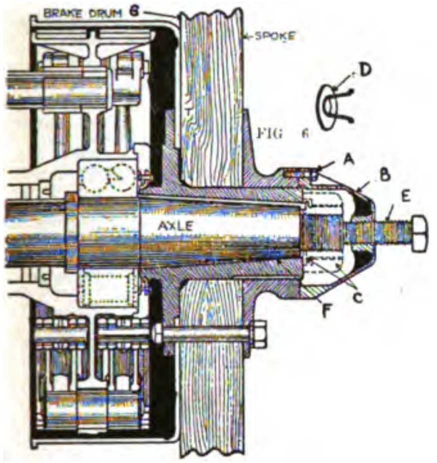
Removing Worm and Wheel Carrier.

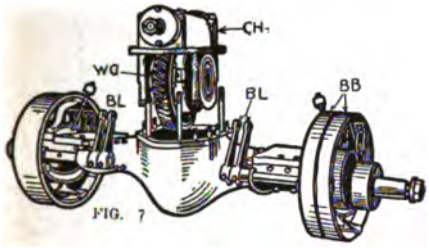
They come out as a unit complete with worm gear, differential, etc. (fig. 7, chart 309B.) Before lifting out carrier, the axle shaft must first be removed and the carrier unbolted from the axle housing.

Procedure: Jack up wheels and remove; take off wheel bearing retainers by unbolting them from brake spiders, (fig. 8); pull out axle shafts, remove

CHART NO. 309-A—Adjusting, Removing and Assembling a Truck Rear Axle. (Sheldon worm drive type as an example.)







nuts which fasten carrier to axle housing marked "remove" (fig. 9.) These nuts are all near the outside edge. Do not disturb any of the other nuts, as they have nothing to do with carrier removal. Fit an eye bolt (any blacksmith can make) into the hole in top of carrier (fig. 9) and lift out carrier with chain hoist by means of this bolt. If entire axle lifts up with carrier, bump housing lightly on each side of carrier with heavy bar at points marked by black squares (fig. 9), applying force downward. Do not use small hammer or hit too hard.

Do not destroy gasket by driving chisel between carrier and housing.

On W-30 and W-50 axles, used on 3 and 5 ton trucks, there is a thrust bearing on each side of the differential as shown in fig. 10. Be careful they do not fall into housing when carrier is lifted out. They can be held in place by reaching hand in axle tubes and smearing with heavy grease, while carrier is being lifted out. It is important that right hand bearing is re-assembled on right hand side and left hand bearing on left hand side Do not interchange.

Reassembling.

Reassembling: Remove drain plug and wash out carrier and housing with gasoline and clean thoroughly. See that all parts are clean. See that gasket between carrier and housing is in perfect condition. Set carrier back in place. On W-30 and W-50 axles put thrust bearings on same side from which removed. On these axles they must be put in place before carrier is dropped in, and must be held until carrier gets down far enough to keep them in their proper position. This can be done by smearing with heavy grease as before mentioned. Bend a short hook of ¼ inch iron, insert the hand holding the hook in axle tube and hook over bearings at bottom, at point X, fig. 10, applying sufficient pressure, pulling towards you to keep bearings from falling out.

Bolt carrier in place. Put axle shafts in place, making sure that the hex part of shaft is shoved well back in hex part of differential case.

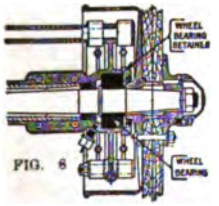
Replace wheel bearings, first washing them with gasoline. Pack bearings and also brake spider, with grease. The grease will then work into and through bearings when shoved back in place. Put on wheel bearing retainers and draw up tight. Replace wheels, being sure key that fastens hub to axle shaft is driven up well. Refill housing with oil. Run axle by hand by twisting on the front end of worm shaft to make sure it is in good condition before attaching the universal joint.

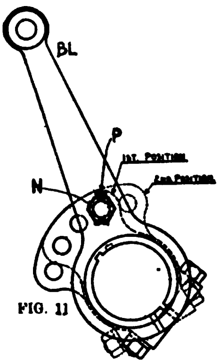
Brakes.

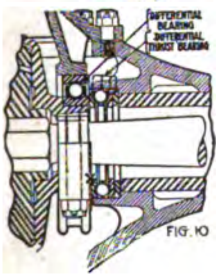
The foot brake is the regular service brake The hand brake is the emergency and for use when it is desired to set brakes while car is standing still. Both brakes on Sheldon axles are internal type, on the small axles they are of the cam type and on the larger sizes the "wrap-up" type. In this latter type the brake action gradually increases automatically.

Adjustment: Equal adjustment is essential. There is no adjustment in the brakes themselves (it being all in the parts which pull the brake levers.) On the late type axles the adjustment is made by a sector attached to the brake pull lever, as shown in fig. 11. To tighten up on the brake levers, simply take out bolt which fastens the sector to the lever, and move the hole in the lever one hole (towards the rear) on the sector.

On older type axles the adjustments were made by simply tightening up the pull rods.







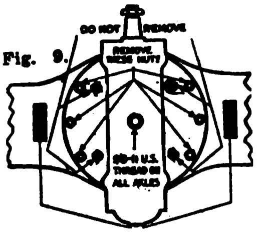
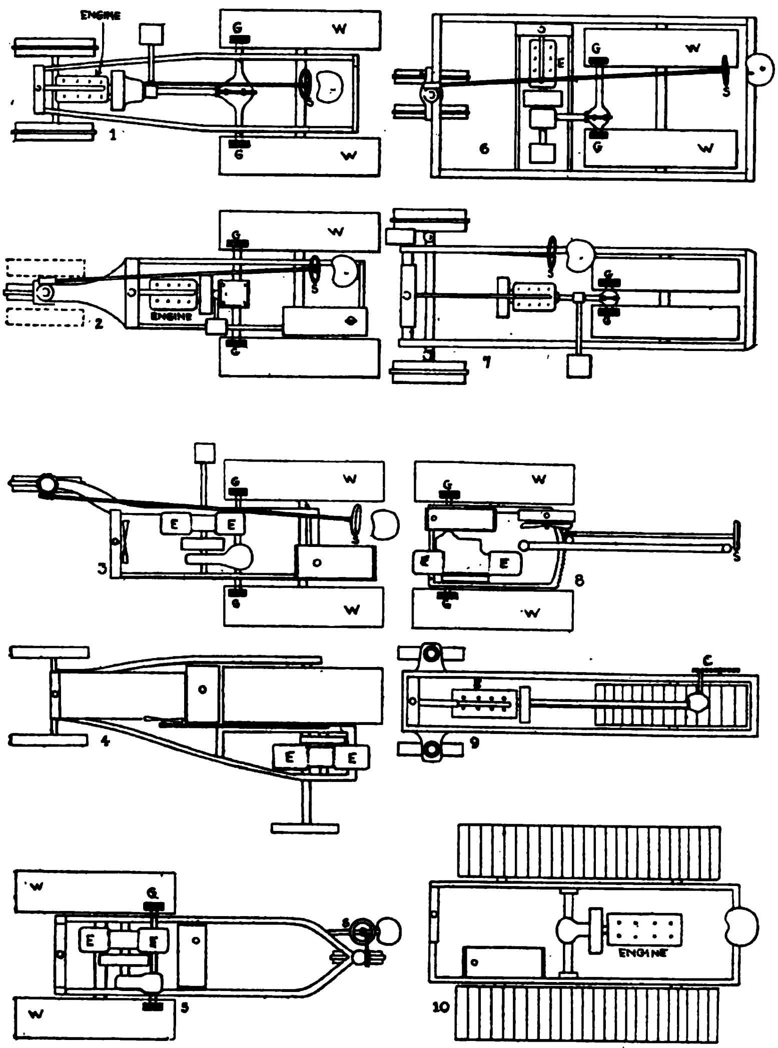


Fig. 9.—Top view of carrier and housing. Bump housing on top at points marked by black squares to loosen carrier from housing.

In braking the truck with the engine with switch off and on low gear, care must be taken. If you intend using engine and low gear on a hill, engage your low speed before you reach the incline, because changing gears while a truck is rapidly descending is apt to strip the gears. The engine used this way makes a powerful brake and saves the brakes. The spark should be given just before reaching bottom of incline in order to start engine before actual bottom is reached.

CHART NO. 309-B—Sheldon Truck Axle—continuation of chart 309-A.



*Tractor Designs.

1—Four-wheel tractor design with two large driving wheels in rear and two smaller steering wheels in front. The front wheels vary in diameter and also in tread. They are generally placed farther apart than shown.

2—Four-wheel tractor design in which two front wheels are so close together as to really serve as a single wheel.

3—Three-wheel tractor design with two large driving wheels and one steering wheel located at one side and in front. The diagram shows a two-cylinder engine.

4—Three-wheel tractor design with a double steering wheel and one very large rear wheel for driving. There is a second rear wheel made quite small for balancing.

5—Three-wheel tractor design using two large driving wheels and one very small wheel in rear for steering.

6—Four-wheel tractor design with large driving wheels in rear and relatively small front wheels for steering. Note the cross method of engine mounting.

7—Unusual tractor design, with two large steering wheels mounted very far apart and with two driving wheels placed very close together at the rear.

8—Two-wheel tractor design to which you can couple any piece of farm machinery. The entire power plant is mounted between the two driving wheels.

9—The combination wheel and caterpillar tractor, with a single caterpillar for driving in the rear and two steering wheels in front.

10—The short caterpillar using a caterpillar, or flat wheel construction at each side. This design has been on the market for some time.

E—is the engine; G—gears driving internal gears in rim of tractor wheels; W—tractor drive wheels. S—steering.

What a Tractor Must Do.

1st—Must work efficiently after six years.
2nd—Must reduce horses to the minimum.
3rd—Must supplant horses.
4th—Must cultivate row crops.
5th—Must plow and cultivate, both.
6th—Must handle two plows under bad conditions and three under good conditions.
7th—Must operate 7- or 8-ft. binder at 2½ to 3 m. p. h.
8th—Must have power to operate road grader, manure spreader etc.
9th—Must have belt power to operate any hay-baler or 24- to 28-in. threshing separator with self-feeder and wind stacker; must operate corn sheller, feed grinder, sawmill, etc.
10th—Must cost less than $1,000.
11th—Must weigh less than 5000 lbs. and be guaranteed one year.
12th—All working parts in oil; self-steering; direct drive for all speeds and belt pulley; speed enough for plowing and road work; low center of gravity.

Class of Work.	LIGHT WORK.	HEAVY WORK.
BELT WORK	Pumping, Washing, Cream Separating, etc.	Feed Grinding, Ensilage Cutting, Shelling, Shredding, Threshing, etc.
HAULING	Hauling People, Farm Produce, Merchandise, etc.	Hauling Grain, Building Material, etc.
FIELD WORK	Planting, Cultivating, Mowing, Raking, etc.	Plowing, Discing, Harrowing, Drilling, Harvesting, etc.

HART NO. 310—Tractor Designs. Diagrams Showing the Different Principles Used.
Motor Age.)
See page 829 for tractor drive methods.

INSTRUCTION No. 48.

*THE TRACTOR: Class of Work. Medium Size Tractor of General Farm Work. Gasoline-Kerosene Carburetors.

Fuel: The tractor was formerly propelled by a steam engine, but is now usually propelled by a gasoline engine, which uses **gasoline** or **kerosene** for fuel. *Two methods of using either gasoline or kerosene is explained in chart 311.

The engine can be either a multiple cylinder, vertical or horizontal type. The same general principle of cycle operation, ignition, etc. is employed as in the automobile engine, therefore we will refer the reader to the Instructions in the book on these subjects.

The drive systems differ however, but the same underlying principles such as clutches, **jack shafts with differentials, etc. are** employed, but of much heavier and larger **design.****

We would advise the reader to send for catalogues of some of the leading tractor manufacturers. These catalogues will give the reader the information on the drive methods and the instructions in this book on engines, ignition, etc. will give sufficient information on the engine. In this way one can gain a good working knowledge of tractors. The two gasoline-kerosene carburetion principles are explained in chart 311—see also index.

A leading concern who has agreed to send descriptive catalogues, pertaining to tractors, to our readers, is the Minneapolis Steel and Machinery Co., Minneapolis, Minn. manufacturers of the famous "Twin City" tractors—see page 832. Other tractor manufacturers are Holt Mfg. Co., Peoria, Ill.; C. L. Best Tractor Co., San Leandro, Calif.; Yuba Mfg. Co., 433 Calif. St., San Francisco, Calif.

The address of three leading gas engine magazines are; The Gas Engine, Cincinnati, Ohio.; Gas Review, Madison, Wiscn. Gas Power, St. Joseph, Mich.

What a Medium Size Tractor Will Do.

The medium-size, medium-priced tractor, operating under average conditions will plow one acre 7 in. deep on 2½ gal. of gasoline and ⅛ gal. of lubricating oil. This, in brief, is the result of an extensive inquiry made by the United States Department of Agriculture embracing data received from 200 tractor users in the corn belt in Illinois.

The information is given in bulletin (No. 719) of the department, which is entitled "An Economic Study of the Farm Tractor in the Corn Belt," and which includes information from the users of tractors of various sizes and on various sized farms.

Best Size Tractor to Purchase.

Belt work represents 50 per cent of the total work of a tractor. For belt work to be thoroughly efficient the engine needs about the **same power** as is required for **four plows,** making the three and four plow outfits the best sizes for general utility on the farm.

Another important conclusion drawn from the data collected indicates the size of tractor most suitable for a given size farm and lays particular emphasis on the fact that the medium-size, medium-priced tractor "appears to have proven a profitable investment in a higher percentage of cases than any others." The sizes recommended for various sizes of farms are:

Acreage of Farm	No. Plows Handled
200 or less	3-plow
201-450	4-plow 3-plow second choice
451-750	4-plow 5- and 8-plow second choice

It is further noted that the smallest farm upon which the smallest tractor in common use—the 2-plow machine—may be expected to prove profitable, is one of 140 acres.

The bulletin further states, that the chief advantages of the tractor for farm work, according to the operators, are (1) its ability to do heavy work rapidly, thus covering the required average in the season; (2) the saving of man labor, and (3) the ability to plow to a good depth, particularly in hot weather. The chief disadvantages are put down as difficulty of efficient operation and packing of the soil when wet.

One significant fact brought out is that the purchase of a tractor seldom lowers the actual cost of conducting the farm and that the purchase of the tractor usually must be justified by increased yield.

With regard to the number of days a tractor is used, the report gives figures which vary from 49 for the 2-plow machine to 70 for the 6-plow machine. Nearly 45 per cent of the tractor users report that they do custom work for others, which would seem to indicate that the tractor is too large to be kept busy on the home farm. The life of tractors, as estimated by their owners, varies from 6 seasons for the 2-plow machine to 10½ seasons for the 6-plow outfits.

Repairs Cost 4% of Purchase Price.

The longevity of the tractor brings up the question of repair expense, and in this connection the bulletin points out that though no accurate statistics are available on this, it would seem fair to count upon probably less than 4 per cent of the initial cost annually. This represents the average for farm machinery generally.

Under favorable conditions a 14-in. plow drawn by a tractor covers about 3 acres in an ordinary working day. Under unfavorable conditions large gang plows will cover less ground per day per plow than will the small ones. Plows drawn by tractors do better work on the whole than do plows drawn by horses, the average depth in Illinois with tractors being 1½ in. greater than with horses. It is stated that the tractor displaces about one-fourth of the horses used on the average farm.

Power Required Depends Upon The Soil.

The resistance that soil offers to the passage of a plow bottom varies from 2 to 20 lbs. per square inch, depending upon the character of the soil.

This being so, a bottom which requires a pull of only about 400 lbs. at the draw bar to turn a furrow 14 in. wide and 6 in. deep, may require as great a pull as 850 lbs. in a soil of different constitution, or a maximum of nearly 1700 lbs. in the most intractable soil.

Therefore the **power of the tractor** must be determined by the **character of the soil and the number of plows it pulls.** One should secure a soil map of his locality from his State Agricultural College and post himself on the relative condition of the soil in his neighborhood and the power required before purchasing a tractor.

---

*See page 829 "Tractors;" 826 Ford Tractor; 827 Holley Kerosene Carburetor for Tractors. See page 831 for kerosene difficulties.

**The tractor engine must stand continued running at, (at least) three-quarter power for an aggregate of several hours steady running, therefore the bearings and parts of engine should be heavier and capable of withstanding this strain.

**Schebler Kerosene Carburetor—Single Type.

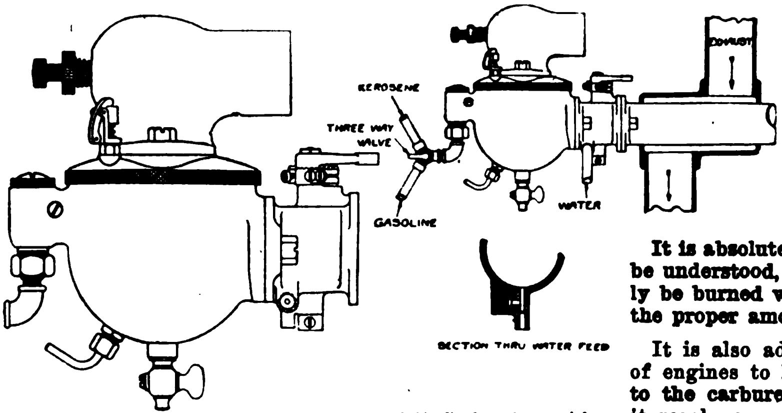


Fig. 1. The Schebler Model D "Single" Carburetor, with special water throttle for use with kerosene on tractor and stationary engines.

Schebler Model D (single) carburetor: The successful use of kerosene is not a problem of the carburetor alone, but involves both the carburetor and a proper design of engine.

It is absolutely necessary and must be understood, that kerosene can only be burned with the application of the proper amount of heat.

It is also advisable on some sizes of engines to **heat the incoming air to the carburetor,** and we find that it rarely occurs that too much heat can be applied to the air supply.

The intake manifold must be kept as hot as possible, perferably by the exhaust heat, for if heat is not applied, there will be a precipitation on the walls of the manifold.

Heat on the manifold has two objects: First, to aid evaporation of the heavier parts of the fuel; second, to neutralize the *refrigeration produced by the evaporation, so that the incoming charge of gas introduced into the engine, is in an intimate mixture and at a uniform temperature.

Users of kerosene have always found it advisable to use water to prevent pounding under heavy loads; and also, water injection prevents excessive deposits of carbon. In this water or kerosene throttle attachment, there is a small hole in the carburetor side of the throttle, through which may be introduced a stream of water controlled by any suitable type of needle valve. While the engine is pulling a load, this needle valve which controls the supply of water from any suitable source, should be opened only sufficiently to remove the pound. When engine is stopped, water must be shut off. The engine must be started and warmed up on gasoline and then can be switched over to kerosene.

**Kingston Kerosene Carburetor—Double Type.

Kingston double carburetor: (shown in fig. 2.) This carburetor is so constructed that either gasoline, motor spirits, kerosene or distillate may be used by shifting of lever No. 31, which operates fuel switch valve No. 29 from one side to the other. The construction of carburetor with two bowls allows gasoline fuel to be supplied to one bowl and kerosene, motor spirits or distillate to the other, so after starting engine on gasoline and after it is warmed up, a switch to the other fuels can be made instantaneously by the shifting of lever No. 31. Then if engine refuses to pick up load, a switch back to gasoline can be made at once.

Adjustment: The fuel supply to each bowl is controlled by needle valves No. 11. The method of adjusting is to turn this valve to the right (first loosen lock screw No. 12) until it is down on valve seat. Then turn back to left one complete turn for preliminary starting. To adjust needle valves correctly, engine must be running up to speed, set spark lever in retarded position and follow out these operations: First turn the needle valve slowly to the right until the engine starts to backfire through carburetor. Then slowly turn to the left until the engine picks up maximum speed. Also notice the exhaust coming from outlet. After engine warms up and proper adjustment has been made, the exhaust should show up clear, no smoke to speak of. Too much fuel produces black smoke.

When engine is operating right, tighten lock screws No. 12. The needle valve lock spring is intended to hold adjustment of needle valve, but to make doubly sure that needle valve is held in proper adjustment the lock screw No. 12 should be set up tight. The needle valve is the only adjustment on the Kingston carburetor.

The auxiliary air is controlled automatically by ball valves see page 152, which takes care of the mixture at all speeds above or below normal speed so that after the adjustment is once made on the needle valves no further adjustments are required.

Stop valve at each of supply tanks should be shut off when tractor isn't being operated. The float valve in carburetor might stick or fail to keep supply of fuel to bowl or float chamber cut off, and it would mean that the carburetor would flood and fuel would run out and be wasted.

For tractor use—fuel must be connected to both bowls from both tanks when operating tractor.

Air washer: The Kingston carburetor (Kokomo, Ind.), uses an air washer, called the Bennett type, manufactured by Wilcox-Bennett Co., Minneapolis, Minn. See page 828 for principle and purpose.

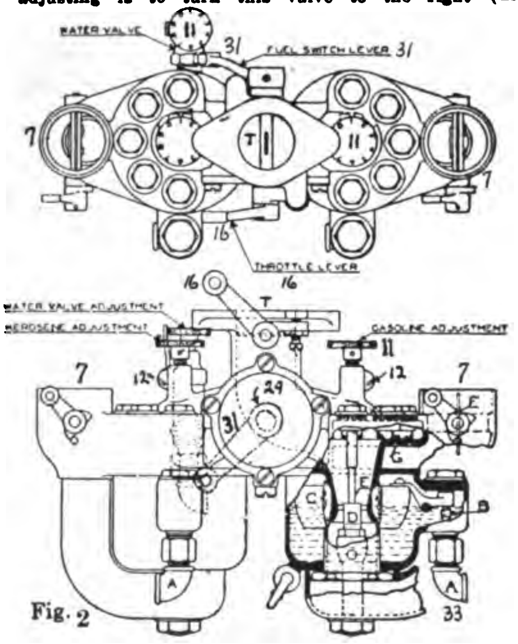


Fig. 2

CHART NO. 811—Carburetors for the Use of Kerosene or Gasoline.

*Cause; as the fuel is drawn through inner pipe, heat is required to evaporate it, consequently heat is drawn from pipe, leaving it cold, evaporation then stops—for this reason extra heating is supplied. (see also pages 155 and 158.) **See page 827 Holley kerosene carburetor and page 831.

Note; it is practically impossible to start an electrically ignited engine with kerosene when engine is cold. Kerosene does not give off vapor until heated nearly to the boiling point of water—it must be heated and kept heated, otherwise it will condense.

INSTRUCTION No. 49.

OTHER TYPES OF ENGINES: Motorcycle, Marine, Stationary Engines. Two Cycle Engine. Diesel Engine. Motor Bob. Re-designing Old Cars. Service Cars. Steam Cars.

Other types of engines are motorcycles, marine, stationary, Diesel, two-cycle, aero, etc. We will not attempt to give detailed explanations in this book—as it would require too much space to properly treat the subject; but to those who are interested in the above subjects we would refer them to Dyke's Motor Manual.

*Motorcycle Engine.

The motorcycle engine is usually a four cycle type of engine and is made with one, two and four cylinders. The air cooled cylinder is in general use. The "twin type" cylinder is the most popular and cylinders are usually placed 42 to 45 degrees apart. Why they are placed 45 degrees apart and such subjects as firing orders, etc. is fully explained in Dyke's Motor Manual, together with complete details of valve timing, driving systems, clutches, transmissions, etc.

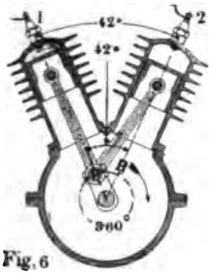
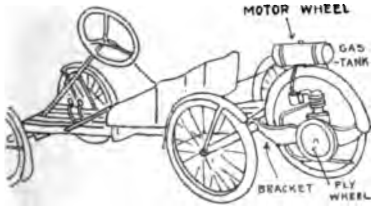


Fig. 6

A twin cylinder motorcycle engin-.

The connecting rods are usually placed on one crank pin, sometimes there are two crank pins—in the latter case the firing impulse would differ. The fly wheels are usually enclosed in the crank case. (see fig. 7, page 74, and Insert No. 3.)

The four cylinder motorcycle engine is also in use and is very similar to the automobile engine, but smaller and lighter.



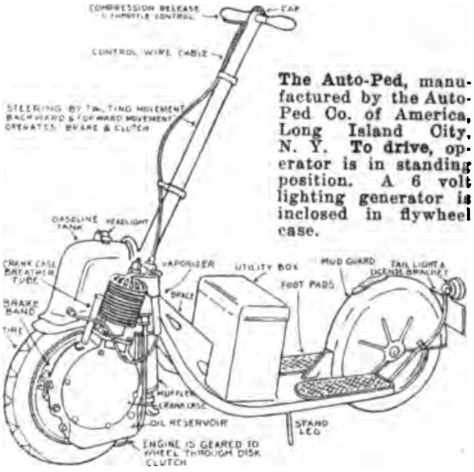
A "Motor-Wheel."

The Smith Flyer is a light motor vehicle made from a four-wheeled buckboard with a Smith "motor wheel" attached to the rear.

This machine though its entire weight is but 135 lbs., is capable of running at 20 to 25 m. p. h. and runs from 50 to 60 miles on 1 gal. of gasoline.

The control consists of a small thumb lever attached to the steering wheel and clutch and foot brakes are the same as those on a regular automobile. The wire wheels are fitted with double tube clincher tires and are 20 in. in diameter. The wheelbase is 70 in. and the tread is 30. The motor wheel is lifted about an inch off the ground by means of the clutch and is cranked by a handle on the drive wheel. By letting out the clutch the wheel is dropped to the ground. Price of this outfit is $135.00.

In winter the wheels can be removed and sled runners attached, making it a motor sled.


COMPRESSION RELEASE & THROTTLE CONTROL
CAP
CONTROL WIRE CABLE
STEERING BY TWISTING MOVEMENT BACKWARD & FORWARD MOVEMENT OPERATES BRAKE & CLUTCH
GASOLINE TANK
HEADLIGHT
CRANK CASE BREATHER TUBE
VAPORIZER
UTILITY BOX
MUD GUARD
TAIL LIGHT & LICENSE BRACKET
FOOT PADS
SPACE
BRAKE BAND
TIRE
MUFFLER
CRANK CASE
OIL RESERVOIR
STAND LEG
ENGINE IS GEARED TO WHEEL THROUGH DISK CLUTCH

The Auto-Ped, manufactured by the Auto-Ped Co. of America, Long Island City, N. Y. To drive, operator is in standing position. A 6 volt lighting generator is inclosed in flywheel case.

Marine Engines.

Marine engines are also built along the same lines as the automobile engine when of the four cycle type, but with the addition of a governor on large engines.

The smaller types of marine or motor boat gasoline engines are frequently of the two cycle type. The two cycle type of engine is explained on page 756.

The marine engine is built heavier than the automobile engine because it is run most at full speed or power for long periods of time, however, on the modern marine engine it is capable of varying speed by use of the throttle and spark the same as the automobile engine.

The ignition for marine engines is similar to the automobile engine, but in many instances the "make and break" system page 260, and oscillating type, page 264, also K. W. is used. On the small two cycle type the jump spark with vibrator coil and battery is used to a great extent, also the make and break system described on pages 214 to 216. In fact, the make and break system is used quite extensively on large four cycle type of marine engine because it is of the low tension type and is not affected by dampness, which is the case where high tension current is employed. If high tension is used, then it must be well insulated because of dampness.

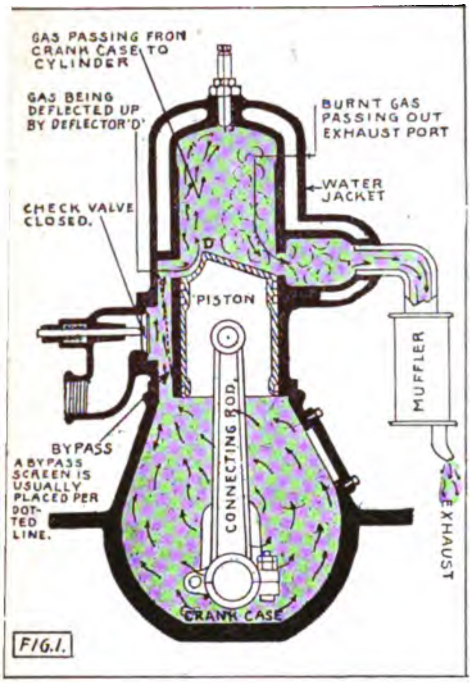
The carburetion is similar, but on some of the larger types of marine engines a double carburetor, using gasoline to start on and kerosene to run on is quite often used (page 754).

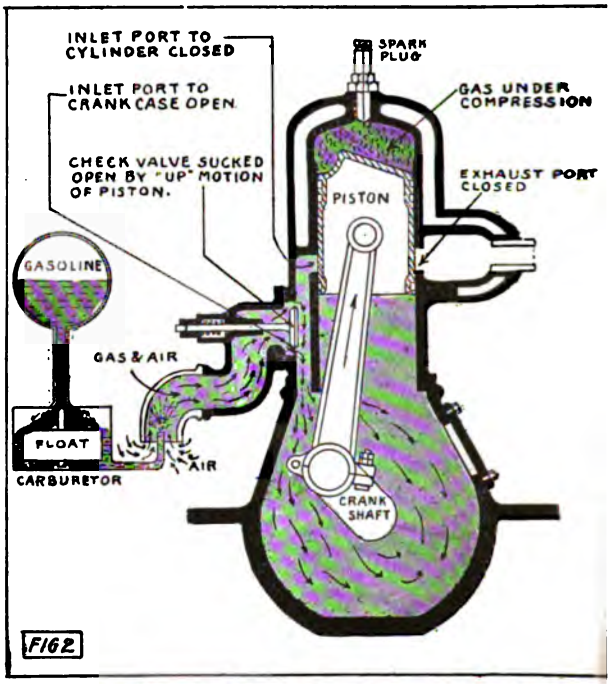
The clutch is used between the engine and reverse gear, and is practically the same principle as an automobile clutch.

A gearbox is some times employed which gives one speed ahead with a lower ratio than the direct drive. The reverse gear is also employed. Sometimes, however, the propeller itself is made so the blades will shift at various angles or pitch, (which

---

*See also pages 843 to 846, and Insert No. 3.


GAS PASSING FROM CRANK CASE TO CYLINDER
GAS BEING DEFLECTED UP BY DEFLECTOR 'D'
BURNT GAS PASSING OUT EXHAUST PORT
WATER JACKET
CHECK VALVE CLOSED.
D
PISTON
MUFFLER
CONNECTING ROD.
BYPASS
A BYPASS SCREEN IS USUALLY PLACED PER DOTTED LINE.
EXHAUST
CRANK CASE
FIG. 1.


INLET PORT TO CYLINDER CLOSED
SPARK PLUG
INLET PORT TO CRANK CASE OPEN
GAS UNDER COMPRESSION
CHECK VALVE SUCKED OPEN BY "UP" MOTION OF PISTON.
EXHAUST PORT CLOSED
PISTON
GASOLINE
GAS & AIR
FLOAT
AIR
CARBURETOR
CRANK SHAFT
FIG 2

Two port two-cycle engine.—Fig. 1. Piston is now at bottom of its stroke. Notice two things are occurring; (1) gas entering cylinder from crank case through "by-pass" port; (2) combusted gas is passing out exhaust port.

Fig. 2. Piston almost at top of stroke. Note two things occurring; (1) gas is being compressed and spark just about to take place; (2) fresh gas is entering crank case from carburetor through inlet port to crank case.

***Therefore with two movements of piston, one up and one down, or one revolution of crank, four actions took place; (1) intake of gas into cylinder; (2) exhaust; (3) compression and intake to crank case; (4) explosion.**

When the piston travels up, a vacuum is formed in crank case which causes the gas to be sucked in through crank case inlet port or check valve.

When piston travels down a pressure is formed in crank case (5 to 9 lbs), which forces the gas in crank case through "by-pass" into cylinder.

A "baffle plate" (D) prevents fresh gas from heading towards the exhaust.

Note when piston is down, pressure in crank case forces the check valve of carburetor to close (fig. 1). When piston is going up, the vacuum formed in crank case sucks check valve open (fig. 2.)

***On a four-cycle type of engine this would require four movements of piston or two revolutions of crank, (see page 58.)**

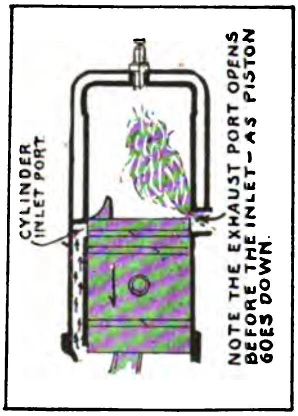

CYLINDER INLET PORT
NOTE THE EXHAUST PORT OPENS BEFORE THE INLET—AS PISTON GOES DOWN.

Fig. 4. Note the exhaust port on a two-cycle engine opens slightly before the cylinder inlet port or "by-pass" opens.

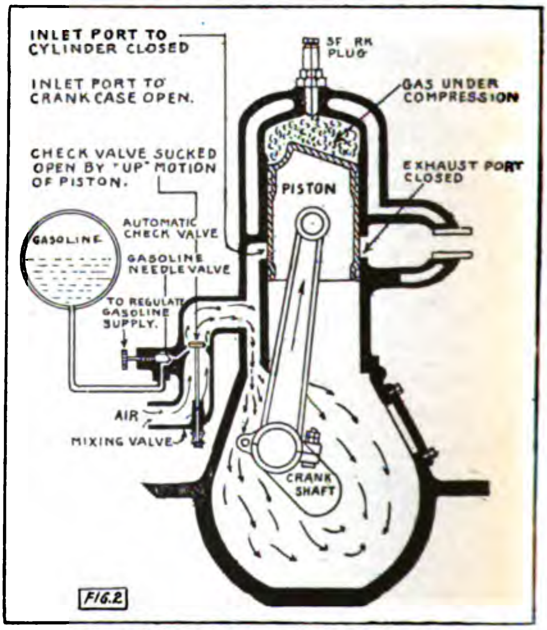


Fig. 3. When a mixing valve is used the check valve is a part of the mixing valve.

When a carburetor is used with a "two port" type of engine a check valve must be used as shown above (figs. 1 and 2). A carburetor can be used however with a three port type without a check valve as the port is opened and closed by piston.

HART NO. 312—Principle of the Two-Port Two-Cycle Type of Internal Combustion Engine.

(See page 757 for other details of a two cycle engine.)

reverses the direction of propulsion) in the place of a speed gear and reverse. (See Dyke's Motor Manual.)

Stationary Gasoline Engine.

This type of internal combination engine is usually of the four cycle type. The cylinders are large in diameter and the stroke is usually larger than the bore. The speed is slow (160 to 600) but constant.

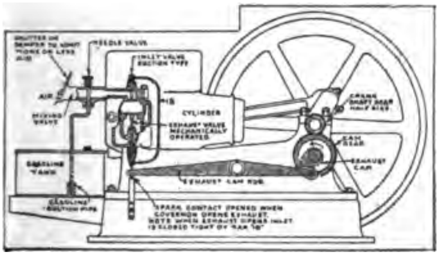

SHUTTER OR DAMPER TO ADMIT MORE OR LESS AIR
NEEDLE VALVE
INLET VALVE SUCTION TYPE
AIR
MIXING VALVE
CYLINDER
EXHAUST VALVE MECHANICALLY OPERATED
CRANK SHAFT GEAR HALF SIZE
CAM GEAR
EXHAUST CAM
EXHAUST CAM ROD
GASOLINE TANK
GASOLINE SUCTION PIPE
SPARK CONTACT OPENED WHEN GOVERNOR OPENS EXHAUST. NOTE WHEN EXHAUST OPENS INLET IS CLOSED TIGHT BY BAR "1B"

Fig 8—A horizontal engine (Witte), with a rocker arm for operating the exhaust valve mechanically The inlet valve is automatic but when the exhaust valve is opened, note the bar (1B) closes inlet tight, although a spring is also provided.

A governor is used to keep the speed at a certain number of revolutions and it is due to the governor action on a stationary engine that you will hear exhausts at uneven intervals.

***Governors are divided into two general types;** the "hit and miss" type and the "throttling" type.

The "hit and miss" principle is generally used with engines using gasoline as fuel and the "throttling" type, with engines using kerosene or lower grades of fuel. The reason why these two principles are used is explained in Dyke's Motor Manual.

The fuel may be either gasoline, naphtha, kerosene or any one of the many other petroleum products of low grades, when properly heated. Natural and artificial gas are also used.

Ignition is usually jump spark on small engines and wipe spark, page 215, or similar to the "make and break," on larger engines.

On some of the engines using a low grade fuel, no ignition is used at all, as for instance the Diesel engine. On others, a hot tube is preheated and serves for ignition. The latter requires complete vaporization of the fuel—all of which is covered in Dyke's Motor Manual.

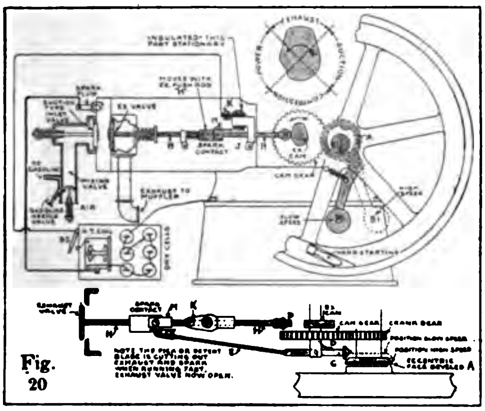


Fig. 20

The "hit and miss" governor action is shown in fig. 20. When speed of engine increases more than governor is set for, the ball (B), by centrifugal action, assumes position (B1). This causes eccentric sleeve (A) to allow pick-blade (E) to catch in notch part of (M). This holds open the exhaust valve and also prevents the spark contact (M) coming in contact with (K), cutting off the ignition. **When the speed decreases,** the ball (B) assumes slow speed position which causes eccentric (A) to move out from hub of fly wheel and disconnect "pick-blade" or "detent-rod" from notch in (M) and the engine fires again and exhaust valve assumes its regular work until speed increases again, at which time the same action is repeated. This cutting in and out by governor is why the uneven impulses one notices on a stationary engine.

Throttling type governor controls the admission of gas into the cylinders instead of cutting off the spark. Principle is shown on page 154, fig. 5, and pages 840 and 841.

Aero Engines.

Differ but little from the regular automobile engine, see pages 900 to 920.

**Diesel Engines.

Are used quite extensively for stationary purposes. It is also the type used on submarines. The fuel is a low grade of oil and ignition is accomplished by air compressed to several hundred pounds pressure, resulting in its temperature being raised sufficiently to ignite the fuel injected into cylinder. (see pages 758 and 587.)

Two Cycle Engine.

The two cycle type of engine is especially adapted for small powered launches, where light weight and medium power are the main requisites.

The two cycle engine is divided into three types; the "two port" which is adapted for slow speed, the "three port" high speed and the combined "two and three port," suitable for power work.

The fuels most generally used are gasoline and kerosene, and on heavy duty commercial boats a still lower grade of oil is used; but on larger engines of this type, the four cycle principle is most generally employed.

The two cycle or "valveless" type of engine derives its name from the fact that the gas is let into and out of cylinder through "port-holes" as they are uncovered by the piston. These ports take the place of valves as used on a four cycle engine.

During two movements or strokes of the piston, the four operations of, intake, exhaust, compression and explosion occur. (see page 756.)

On a four cycle type of engine, page 58, this would require **four movements** or strokes of the piston.

The terms two-cycle and four-cycle are not appropriate. Originally the terms were two-stroke-cycle and four-stroke-cycle, and these were the more nearly correct. See page 756.

Gas Producers.

Are not internal combustion engines, but are generators of gas from hard coal, coke or charcoal.

There are two types, the pressure type and the suction type. **The pressure type** stores the gas into a tank or gasometer. The gas is then supplied to any regular type of gas engine as a fuel.

With the suction type, the gas is generated in the gas producer, then passes through a washer and is then drawn into cylinder of engine by suction of piston. See Dyke's Motor Manual.

---

*See pages 839 to 842, 153 and 154 for throttling type governors. **One manufacturer of the Diesel Engine is the Busch-Sulzer Diesel Engine Co., 2nd and Utah Sts., St. Louis, Mo.

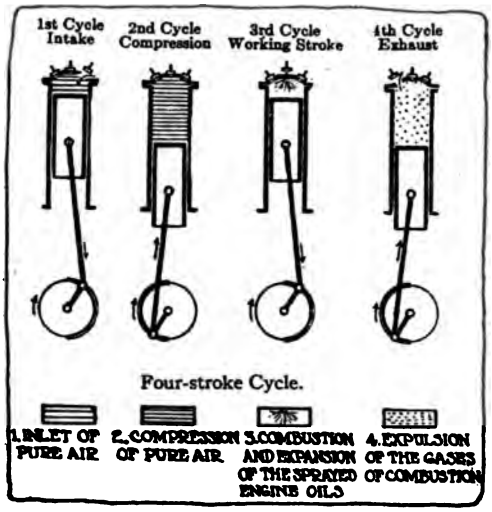

1st Cycle Intake
2nd Cycle Compression
3rd Cycle Working Stroke
4th Cycle Exhaust
Four-stroke Cycle.
1. INLET OF PURE AIR
2. COMPRESSION OF PURE AIR
3. COMBUSTION AND EXPANSION OF THE SPRAYED ENGINE OILS
4. EXPULSION OF THE GASES OF COMBUSTION

Fig. 1—Diagrammatic illustration of the principle of the four-stroke cycle Diesel.

Diesel Four Cycle Operation.

Stroke 1—Admission. During this stroke the piston travels downward and the cylinder is filled with air only—at atmospheric temperature and pressure, no fuel being introduced into the cylinder during this stroke.

Stroke 2—Compression. During this stroke the piston travels upward and the air taken into the cylinder during the preceding stroke is compressed to about 500 pounds per square inch, resulting in its temperature being raised to about 1000 degrees Fahrenheit, or sufficient to positively ignite any liquid fuel injected into it. No fuel is introduced into the cylinder until the completion of this stroke.

Stroke 3—Power or working stroke. When the piston has reached the upper end of the compression stroke (or slightly in advance) the fuel valve opens and a measured quantity of fuel oil is gradually injected into the cylinder through the atomizer which breaks it up into a finely divided spray, the orifices in the atomizer being so proportioned that at full load the admission of fuel is distributed over about 10 per cent of the power or working stroke, the rate of admission being such that there is no appreciable rise of pressure within the cylinder beyond that of compression pressure.

The quantity of fuel oil delivered to the atomizer chamber is adjusted to the various load requirements by the action of the governor upon the fuel pump.

The injection air at 750 to 950 pounds per square inch is furnished by a small two or three stage compressor, driven from the engine shaft. To prevent the possibility of preignition, this air is thoroughly cooled before being delivered to the atomiser.

When the measured charge of fuel has passed into the cylinder, and during and following combustion, the gases expand and drive the piston downward. When the piston reaches the lower end of the stroke (or slightly in advance) the exhaust valve opens and the remaining pressure is released to atmosphere.

Stroke 4—Exhaust. During this stroke the exhaust valve remains open, the piston travels upward and the products of combustion are expelled from the cylinder, completing the cycle.

Principle of the Diesel Engine.

The general arrangement of the valves and fuel injection apparatus of the Diesel motor, as illustrated in Edward Butler's book on "carburetors, vaporizers and distributing valves," is shown in fig. 2.

The cylinder C has very little clearance between the top of the piston F and the bottom of the combustion chamber B at the end of the compression stroke, at which moment the injection valve operated by the lever J will be opened, to permit the injection of a charge of fuel forced (during about 20 degrees of the crank revolution) from the supply pipe P assisted by an atomizing charge of super-compressed air through the pipe D.

The cage containing the injection valve is water-jacketed, water entering and leaving by pipes W.

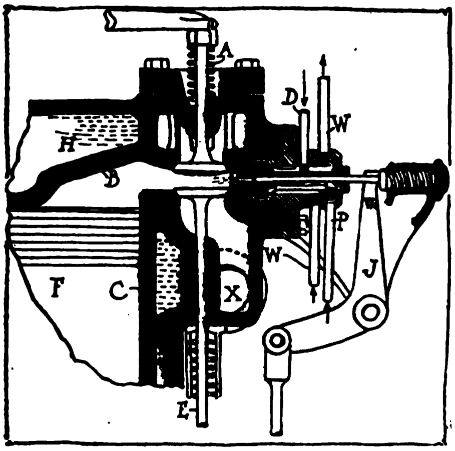


Fig. 2—Section of the Diesel engine. The oil is forced into the cylinder by air pressure.

The operation of the air admission valve A and the exhaust valve E is mechanically controlled in the conventional manner. The movement of the fuel-admission valve is very slight, giving a narrow annular opening for the entry of the oil. Surrounding the valve spindle are a series of brass washers perforated parallel to the spindle by numerous small holes.

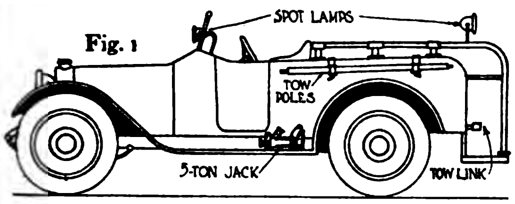
The oil is pumped into the space around the valve spindle near its middle, and by capillary action finds its way between the washers and into the perforations.

The air for fuel injection is admitted behind the oil; and because of its high pressure, blows the oil into the cylinder when the valve opens.

The amount of oil admitted is regulated by the governor, which controls the time of opening of a by pass connecting the discharge and suction sides of the oil pump. At light loads the oil is pumped to the fuel valve for part only of the admission period, and air alone will enter past the valve for the remainder of the period.

CHART NO. 312-A—The Diesel Engine. Note second paragraph from top, how the **fuel is ignited.** (Electric ignition is not used.)

Fig. 1



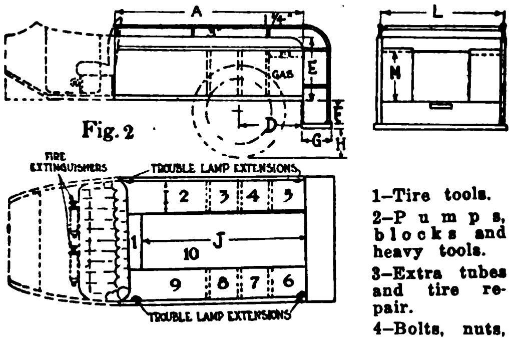


Fig. 2

1–Tire tools.
2–Pumps, blocks and heavy tools.
3–Extra tubes and tire repair.
4–Bolts, nuts, and small repair parts.
5–Gas can.
6–Oil can.
7–Bolts, nuts, screws.
8–Small repair parts.
9–Tools.
10–Towing dolly, shovel, axe, pick, bars, battery, spare tires, etc.

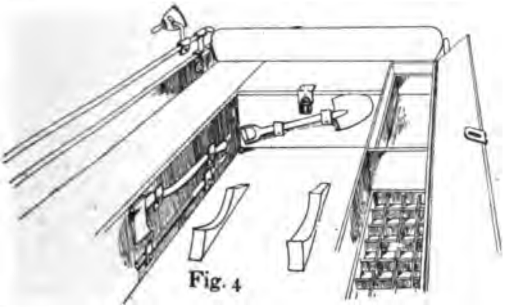


Fig. 4

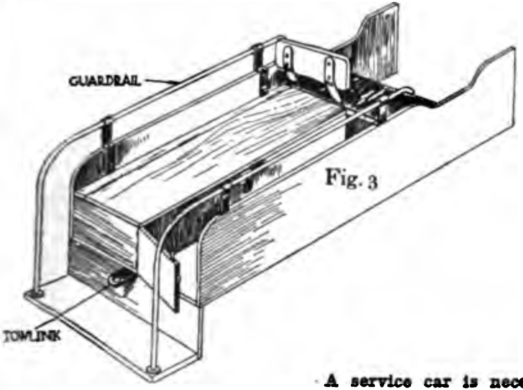


Fig. 3

Fig. 7

Table of Service Car Body Dimensions

As Taken From Representative Detroit Service Cars

Car	Model	A	D	E	F	G	H	I	J	L	M
Hudson	4–37	70	39½	20	14	12	15	12	70	43½	18
Cadillac	53	84	28	23	12	12	19	14	53	55	16
Studebaker	4–58	58	25½	25	8	10	18	12½	55	45	11
Ford	T	48-up	0-up	15¾	...	..	..	..	48	34	15¾
Chevrolet	4–90	55	20	16	8	9	..	13*	43	32	13½
Dodge	...	60	35	19	11	8	16	12	43	47	17
Chalmers	5–15	68	31	24½	10	11	12	10	48	45	20
Hupmobile	32	47	23	15	9	5	..	..	50	41	13
Paige	6–46	68	30	22	10	10	..	12	52	54	12

(*—seat on one side only.)

All dimensions in inches

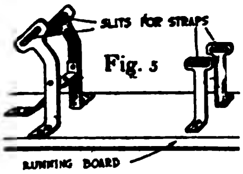


Fig. 5

How To Make a Service Car.

A service car is necessary in all up-to-date garages. It bears the same relation to a service station as does an ambulance to a hospital. It is a traveling representative of the service station and should impress the public that quick, clean and efficient service is given.

Any old chassis can be utilized for the purpose and by following the dimensions in table, fig. 7 a very attractive and serviceable car can be constructed.

One very important point to bear in mind is that the service wagon must be attractive in appearance—clean, well-painted, and it must run smoothly and quietly.

It will be one of the best investments you can make.

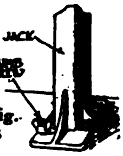


Fig. 6

Painting: For example, cars giving Chalmers service are painted English vermillion, with black hood and running gear. Hudson service cars are white, with black trimmings. If the dealer is giving service on a particular make of car he should find if a standard service car color is used. If not the car may be painted any bright color that will give distinction.

Fig. 1—After studying hundreds of service cars in dozens of the largest cities and many smaller ones, Motor World believes that a design of this general kind is best. Note particularly the method of carrying the towing pole, the jack mounting on the running board and the location of the several spot lamps.

Fig. 2—Here is a detail drawing of the body shown above. The lettered dimensions on the drawing are given in the table fig. 7; the figures refer to the location of the various tools and accessories.

Fig. 8—An alternative type of body, built especially for very light chassis, often is desirable, in which case the arrangement can be made something like this. This is a body that is used quite successfully by the Chevrolet company in Detroit. There is an almost endless variety of arrangements, and in laying out a car a shop foreman should be guided by the particular class of work he expects to be called upon to do.

Fig. 4—This is a view of the interior of the service car shown in fig. 1. Note the chocks and the neat arrangement of the tools, the seat at the right not being shown, so that the compartments are visible.

Fig. 5—This is a detail drawing of the jack mounting shown on the service car illustrated in fig. 1. In this case 5-ton jacks are carried, though any size can be substituted. Get them big enough to care for the heaviest work to be done and they will also serve for light work.

Fig. 8—The service jacks can be carried bolted to the running board, like this, thumb-screws being used for quick action.

Fig. 7—This table of dimensions, which is to go with the drawing fig. 1, has been compiled after a careful and critical study of hundreds of service wagons. The figures given are intended to be for average requirements of the average service car built on the various chassis which are listed in the table.

CHART NO. 818—A Service Car; How To Construct. (See pages 821 and 822 for converting a Ford car for Commercial use.)
(From Motor World, by Mr. S. Thornton Williams.)

Re-Designing and Speeding Up Old Cars.

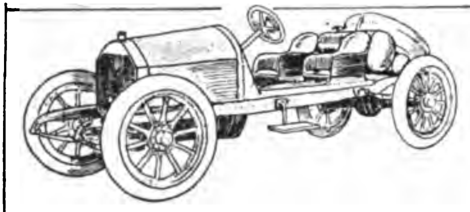


Fig. 1—Usual form of racy roadster with bucket seats

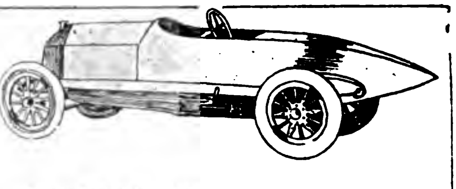


Fig. 2—Type of body designed for minimum wind resistance

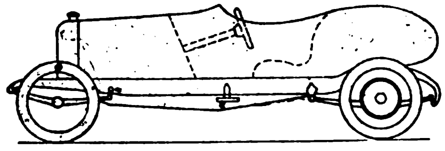


Fig. 3—A suggested body design for class and wind resistance lowering

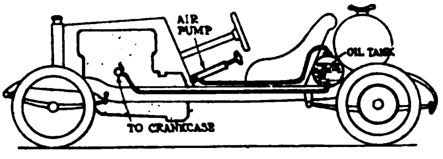


Fig. 4—One way to fit auxiliary oil system when tank is at rear

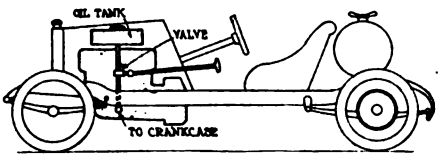


Fig. 5—Extra oil tank at top of motor, supply from which is controlled by a valve

Generally speaking, the replacing of the old body with a raceabout type is the most important consideration in rejuvenating an old one, but usually the steering column has to be lowered and sometimes a leaf removed from each of the springs to make up for the lighter body, although this latter is not essential by any means. All too often, old cars have springs that are too weak for the heavy bodies with which they were originally burdened, and these prove just about right for the lighter bodies.

Changes in the valve timing are often made to assist in the speed possibilities, and sometimes different axle gears are used so as to raise the ratio between engine and wheels. It must be borne in mind, however, that many chassis and engine changes of this kind will work to the disadvantage of the car for slow running. They will serve to make the machine faster, but they hamper the engine's ability at low throttle running. In other words, it will not have the flexibility on high gear.

Body being the first consideration in making a speedster, it might be well to take up some of the possible designs. For Fords* the combinations offered by concerns making a business of this kind of work are indeed attractive. You can get a complete outfit of radiator, hood, floor boards, rear gasoline tank, and body in the neighborhood of $100, and it is surprising what a difference these make. Other concerns make a specialty of the body proper exclusive of radiators, hoods, tanks, etc., and it is also possible to get bucket seats alone, so that, with a little ingenuity quite a presentable racy-roadster can result from combinations with old chassis.

Dressing up the cars: The illustrations herewith are suggestions as to how to dress up the chassis in several ways. Many of the most attractive of the types that have come to our attention have been made by enthusiasts, with the assistance of a tinner or other tradesman of similar experience. The usual form of racing roadster is shown in fig. 1.

This has bucket seats that are attached directly to the floor with gasoline and oil tanks and tires carried at the rear in a way that adds to the appearance. The dash is sloped slightly, and the steering wheel brought down so as to make steering easy with the seats in this low position. Sometimes running boards and mudguards are entirely eliminated as shown, with steps at the side to assist in getting into the car, while often the owner prefers to have the mud-guards as a matter of protection. They retard the speed a little where fast driving is the thing most sought, but it is a question if they do not also add to the appearance. Usually the hood is sloped somewhat as an added feature. Undoubtedly a high, narrow radiator (page 190) also does its part in improving the looks, but this is carrying the alterations to quite an extreme.

Wind resistance is quite a factor in hampering the speed of a car, far more of a factor in fact, than most motorists realize. To attain greatest speed, the head resistance, by which is meant the surface against which the wind strikes, must be made as small as possible, and the body must be so smooth along its length that there are no obstructions against which the wind can strike and thus form eddies. In other words, the air should be allowed to slide along the body without having to come in contact with lamps or other obstructions.

Getting streamline effect: This is the streamline idea, and in order to carry it out best, the radiator should be as narrow as consistent with proper cooling, the hood should slope, and the rear should taper. If a taper tail is fitted, this forms the most perfect form of body so far as wind resistance is concerned, providing the rest of the body conforms with it. Tires and gasoline tanks obstruct the air, and wherever possible they should be placed within the tail, if one is fitted. It is not always easy to keep some parts from offering wind resistance, for generally the spare tires have to be carried outside. Two body designs that carry out the wind resistance reduction theory very well are shown in figs. 2 and 3.

Thus, even if the engine and gear ratio are not altered at all, more speed is obtainable by cutting down the wind resistance and fitting the lighter body. Usually from 10 to 15 miles per hour is added to the possibilities of the vehicle by these changes alone and sometimes, with engine specially tuned for speed work though timing and valves are not altered, it is possible to get even more. The reduction in wind retardation, however, permits of raising the gear ratio sometimes where it would not be practicable to do so otherwise. Often if a car is fitted with a standard ratio of 4 to 1, say, this can be raised to 3 to 1, if the other factors have first been changed.

CHART NO. 814—Re-Designing and Speeding Up Old Cars. (From Motor Age.)

*See also Ford Supplement.

—continued from chart 814.

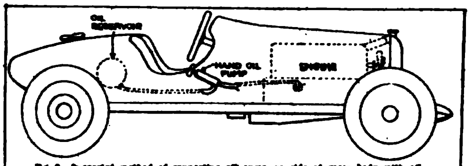


Fig. 3—Suggested method of connecting oil pump on side of racer body with oil tank in rear and motor crankcase

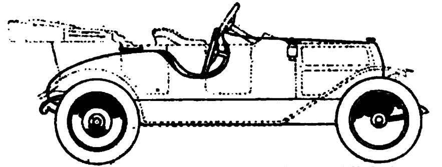


Fig. 4—A streamline racing speedster body applied to a Hudson model 33 chassis

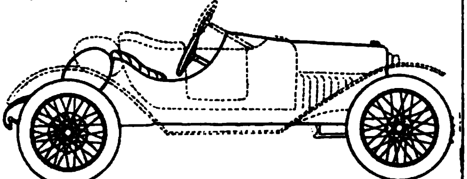


Fig 5—Sketch showing how a model 30 Buick may be stripped down into a speedster

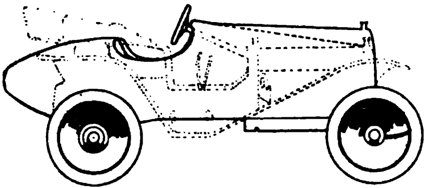


Fig. 6—Racing body design for model 20 Hupmobile. The heavy lines show what only be done with a high, narrow radiator. Using the regular radiator the hood would appear as shown by the heavy dotted lines

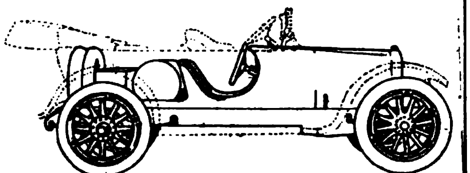


Fig. 7—An Overland model 80 may be stripped down to appear like this illustration. The new cowl may be continued to the sides of the seats

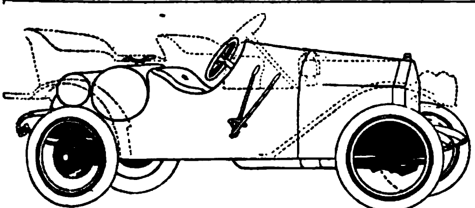


Fig 4—A model 21 Buick can be rebuilt to appear as shown in this sketch. This follows the reader's idea of a gasoline and oil tank in the rear

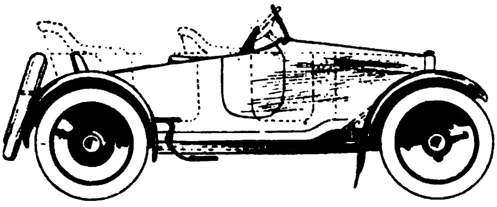


Fig 4—Artist's conception of speedster body to modernize Overland Model 51. There is an auxiliary seat in the rear deck

Some of the mechanical points that can be changed are the carburetor setting, adjusting it so that while it may not allow the engine to throttle down so well, it works better at the higher speeds. Usually this is the result of making the mixture leaner, and it ordinarily has the added advantage of preventing the engine from getting so hot.

The magneto or other ignition apparatus can also be altered to conform to the higer speeds, this usually being a matter of setting the timing ahead a slight amount, the exact extent of which depends entirely upon the engine.

More power, and consequently more speed, is often obtainable by reducing the vibration through accurately balancing the pistons.* In other words, a set of pistons of exactly the same weight should be used if possible. Often speed bugs have gone so far as to drill the connecting-rods in order to lighten these reciprocating parts as much as possible, but this ordinarily is not advisable, for the rods are undoubtedly weakened thereby, and not being designed for such treatment, they often will not stand the strain (determined by amount of stock in rods).

Extra lubrication is often advisable where the owner wishes to maintain excessively high speeds for any length of time. This can very simply be attained by rigging up an auxiliary supply that will feed directly into the crankcase. An easy scheme to employ is shown in fig. 4, chart 814. A hand pump is pivoted to the floor of the car as indicated, and an air line runs from it to the top of the oil tank at the rear. The delivery pipe from the oil tank to the crankcase runs from the lower side of the tank, and thus the air pressure due to the hand pump forces the excess oil to the engine.

Sometimes an auxiliary oil tank is fitted to the engine and under the hood if there is room. There is a pipe connecting from the bottom of this to the crankcase, and a valve is interposed in the pipe to allow of controlling the oil from the seat by means of a rod.

Such auxiliary devices as these and the altering of the camshaft and valves are extremes to which the average man cannot go, although they are conducive of surprising results where intelligently carried out. (see Ford Instruction.)

Racing Car Exhaust Effect.

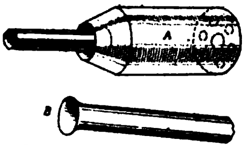


Fig. 6—Noise amplifying exhaust to give racer sound to small engines

Fig. 6—The low rumble in the exhaust of a racing car is due generally to the design and construction of the engine. One method to obtain this effect is to magnify the sound as in fig. 6. This shows a large sheet steel cylinder. A, fitted with a conical-shaped head into which the exhaust pipe is led as shown. The end of the exhaust pipe should be flared, as shown at B. The rear end of the cylinder A is covered with a metal cap into which several holes have been made. We have seen this arrangement used very successfully on a small high-speed engine, the exhaust of which sounded like a high-powered racing car. Many of the racing cars give out a metallic sounding exhaust because the exhaust pipes and headers are made of thin metal. This thin metal will vibrate under the periodic exhaust impulses and set up a peculiar ring of its own. Of course, the thinner the exhaust pipe the better will be its radiating effect.

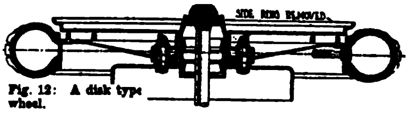
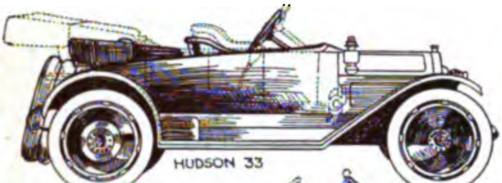
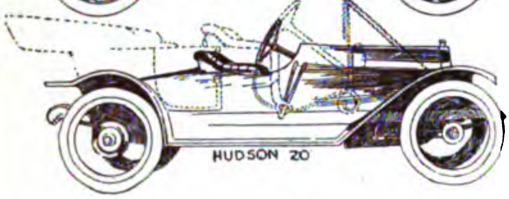


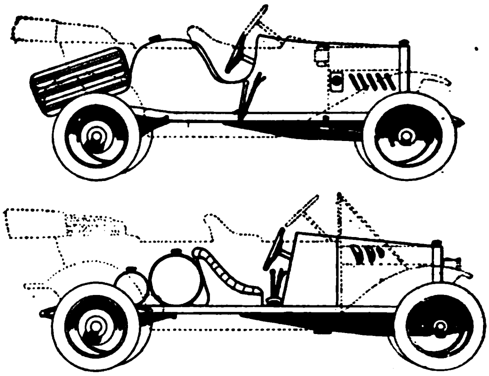
Fig. 12: A disk type wheel.

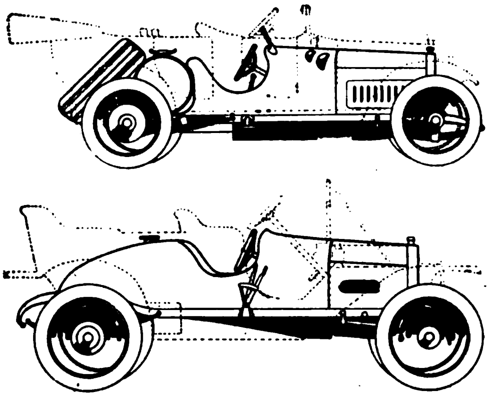
CHART NO. 814-A—Re-Designing and Speeding Up Old Cars—continued.

The different methods employed are shown in the dotted lines. For instance in the Buick model 30, the ide is shown whereby bucket seats are installed and a cowl is built around the seats. The gear ratio is changed t 3¾ to 1. *See page 781. See also Ford Supplement where to obtain aluminum pistons, etc.






Figs. 2 and 3—Maxwell 1913 Mascot converted into speedster. A 1912 E.M.F cut down at small cost


Figs 4 and 5—Speedster body for 1915 Cadillac eight with cantilever springs to reduce overall height. Model 19 Haynes cut down with racer body

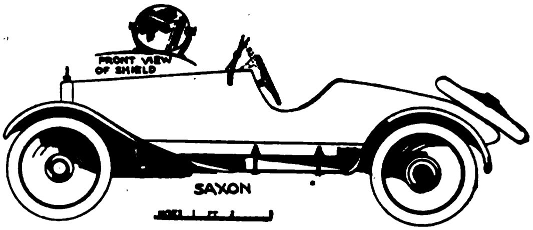
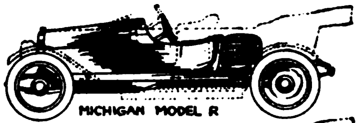
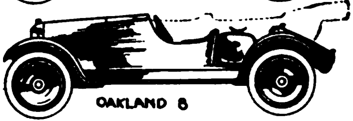


Fig. 6—Speedster body on Saxon six designed after ideas of Motor Age reader





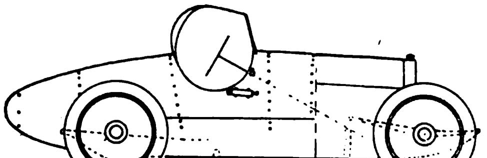
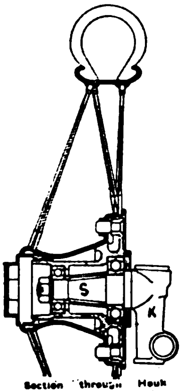
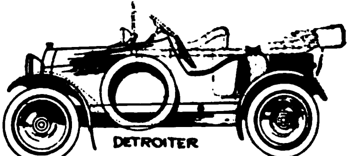
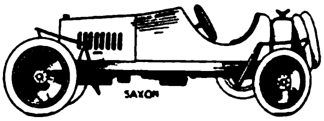


Fig. 3—Diagram showing how a Motor Age reader rebuilt a 1911 Regal



Section through Houk wire wheel. The wire wheel hub is shown in black





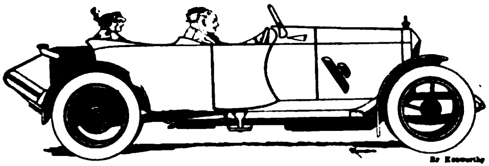
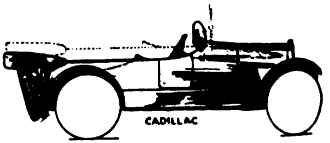
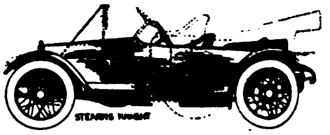


Fig. 2—An exclusive Motor Age design for a four-passenger touring roadster





Addresses of Body Builders.

Following are the addresses of a few concerns who specialize in bodies made to order: Charles E. Schutte, Lancaster, Pa.; Auto Remodeling Co., 1501 Michigan Avenue, Chicago; Detroit Auto Products Co., 38 Sherman Street, Detroit; Lehman Mfg. Co., Cannelton, Ind; Auto Sheet Metal Works, 2301 South Wabash Avenue, Chicago; Wright, Cooler & Hood Mfg. Co., 4867 North Clark Street, Chicago, etc. Submit sketches for quotations from the above concerns.

Wire wheels—help the appearance of a car. Some of the manufacturers are: Standard Roller Bearing Co., Philadelphia, Pa.; Craftsman Motor Corp., 2815 Wabash Ave., Chicago; Great Western Wheel Co., La Porte, Ind.; Houk Mfg. Co., Buffalo, N. Y.; Castle & Kyte, Detroit, Mich.

CHART NO. 315—Re-Designing Old Cars—continued.
(Motor Age.)

The Stanley Steam Car.

Engine—double acting, taking steam at each end of cylinder. Slide valve—built in a unit with rear axle and driving through a spur gear on differential (GD) (fig. 3). Crank shaft spur gear (DG) is the drive gear on engine.

The valves which control the admission and exhaust are operated from eccentrics on the crank shaft and through a link motion (LM), through (LSS) which is connected with left pedal (fig. 2) and controls the range of motion of the valve.

There are three passages when the valve is open for a large part of the stroke. This admits steam at boiler pressure and shuts the valve a certain distance before the piston reaches the bottom of its stroke. For the rest of the traveling the piston is driven by the expansion of the steam. Pressing the pedal (T) forward until it catches or hooks up causes the valve to close earlier. This means that less steam is taken from the boiler and the piston is driven a longer distance by the expansion. This, of course, is more economical of steam and the condition for normal running.

The longer valve opening is used for starting and practically for nothing else. With the pedal pressed forward the operation of the valve is reversed so that the engine will run backwards, this giving the reverse motion.

After leaving the engine, the steam goes to feed water heater thence to the top of the radiator, upon passing through which it condenses into water and this water flows back to the main tank. Differing load and road conditions entail the loss of some steam, and it is this loss which has to be made up by refilling the water tank. However, sufficient water can be carried for 200 to 250 miles of ordinary running, or, in other words, it takes this amount of ordinary running before the slight loss of steam is equivalent to the whole tank full of water, which is about 20 gal. and is placed underneath the car, below frame.

Boiler—Fire tube type. The flues being welded by the acetylene process to the bottom head.

Burner—Just as we have to open the throttle when we want more power from the gas car, so do we want more heat from the burner when we want more power from the steam car.

How kerosene is used: The kerosene under pressure is first led through a long coil placed on top of boiler, where the exhaust gases of combustion yield up part of their waste heat, by preheating the kerosene. From this top or heating coil the kerosene passes by way of the automatic control and main burner valve to the vaporizer (located in the fire) here the hot kerosene is transferred into a true gas and after being mixed with a definite amount of air is burned with the blue "Bunsen" flame.

Questions Answered Relative to the Stanley Steam Car.

(Q-1) Where is the engine located?

(A-1) The engine is located on the rear axle and supported from the rear axle differential housing. It is swung at other end, from the car frame by means of a spring strap hanger.

(Q-2) How does engine drive rear axle?

(A-2) The engine frame made up of four members, are carried through the differential housing, turning in an oscillating block at that point. Thus the engine and rear axle become a unit. The gear teeth of the engines main drive meshing with those of the differential.

(Q-3) What is the ratio of gearing?

(A-3) This depends upon the size, power and type of car employed, in the older models it is 2:1 and in the later models 1½:1.

(Q-4) Where is boiler located?

(A-4) The boiler is located in front of the dash, underneath the hood and behind the condensor which is also a radiator.

(Q-5) What steam pressure is usually carried?

(A-5) All stock cars, regardless of model operate on 600 pounds pressure normally. However for speed purposes this pressure is run up as high as twelve hundred to fifteen hundred pounds.

(Q-6) What is the average time required to raise sufficient steam pressure when cold?

(A-6) The initial time of steaming a car when cold will take approximately fifteen minutes. This includes filling of the tanks and boiler, as well as the raising of steam pressure.

(Q-7) What time if standing awhile after having been used?

(A-7) No time whatever required for raising running pressure. Inasmuch as that pressure has been maintained.

(Q-8) What is the fuel consumption?

(A-8) One of the Stanley five passenger, big touring cars was run for three consecutive months, making an average of twelve miles per gallon of coal oil. On long runs, this figure is increased as high as sixteen or seventeen miles per gallon of coal oil.

(Q-9) How are the various speeds controlled?

(A-9) From zero to the world record, is obtained by the opening of the throttle, the handle of which is located on the steering wheel. There is no other movement on the part of the operator for increasing or retarding his speed, other than the throttle.

(Q-10) What is the water capacity and consumption?

(A-10) The water capacity is 20 gallons carried in a tank, beneath the car frame and filled through a radiator. This capacity is sufficient for a days run. We have known it to go as high as 350 miles.

(Q-11) Mention the control levers, valves, etc.

(A-11) When starting out with a car, a valve is opened which places the car under automatic control from that time on. When brought to a stop, this valve is closed. The operating controls are the throttle, the service and emergency brakes and reverse.

(Q.12) Where are control parts located?

(A-12) The throttle subimposes on steering wheel. The foot brake, usual position. Reverse, a foot brake. The emergency, a handle brake, located on the side of the car.

(Q-13) What are the advantages of a steam car?

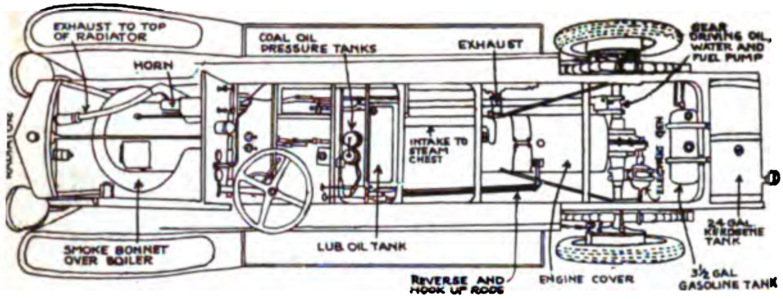
(A-13) Entire lack of vibration; freedom from gear shifting; absence of clutch; absolute flexibility; more power per weight than is possible in gasoline cars; a car that cannot freeze up in winter weather; simplicity of controls, but 32 moving parts, counting the wheels, low cost of upkeep; greater tire mileage; small depreciation factor; no smoke or steam visible in cold weather.

(Q-14) What are its disadvantages?

(A-14) These have in later models been overcome, but formerly they were: shape of hood; necessity for firing up; likelihood of freezing; nenessity of taking on water every fifty miles (before condensing system used); steam in street.

Note:—The above questions were answered by Mr. M. H. Ward of the Stanley Motor Car Co. of St. Louis, Mo. Mr. Ward also supplied other data for this subject.

Fig. 1—Plan view.



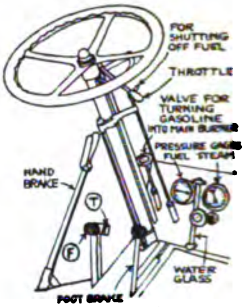
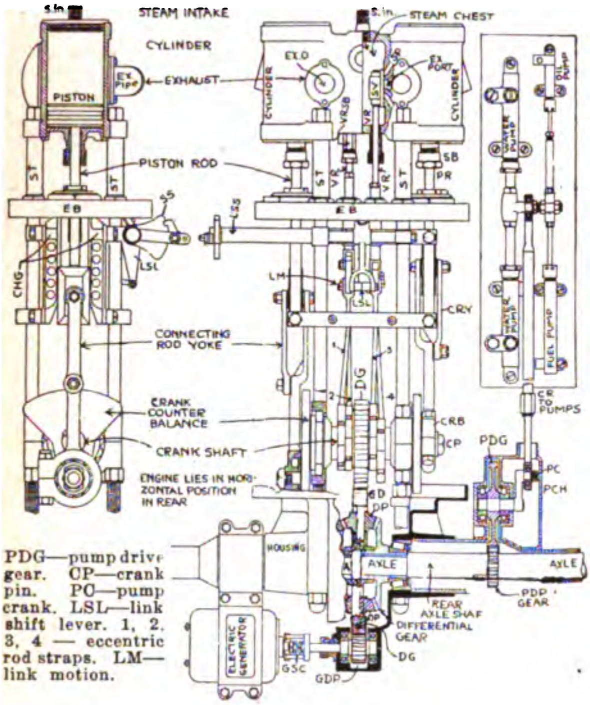

FOR SHUTTING OFF FUEL
THROTTLE
VALVE FOR TURNING GASOLINE INTO MAIN BURNER
PRESSURE GAGES FUEL STEAM
HAND BRAKE
T
F
WATER GLASS
FOOT BRAKE

Fig. 2—Control.

Fig. 2—Control of car: The left pedal gives the two valve positions for forward running and the reverse. (T) is pressed forward half way after starting and left there. (F) is the reverse pedal, and is pushed full forward when car is reversed. The right pedal operates the service brake, the lever, the emergncy brake. The throttle is the only control used while running. A little lever partly concealed by the throttle lever, is for shutting off the fuel when making a long stop. When starting from dead cold, the valve turning gasoline into the main burner is used. On dash the left gage shows the fuel pressure and is seldom looked at. The right gage is the steam pressure. In the center is the water glass that is only carried as an emergency indicator in the event of any trouble in the water feed system.



PDG—pump drive gear. CP—crank pin. PC—pump crank. LSL—link shift lever. 1, 2, 3, 4 — eccentric rod straps. LM—link motion.

Fig. 3—Stanley engine, rear axle and pump gear. The pumps are really mounted forward on chassis and are driven by a crank off rear axle. Electric generator also rear axle driven.

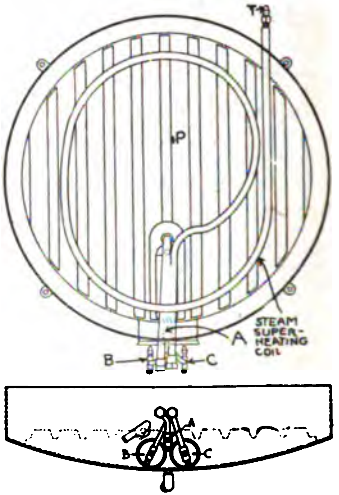


Fig. 4—Stanley Burner—A is the gasoline nozzle for the pilot light and B & C the two main burner nozzles for coal oil or main fuel.

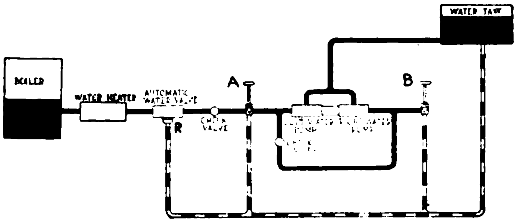


Fig. 5—Diagram of water system of Stanley steam car. Water is pumped towards the boiler by one or two pumps, according to the positions of the hand valves A and B. After reaching a proper level in the boiler the release valve R is opened and the water then goes back to the main tank, whether the pumps are both working or not. In practice the left pump always is in use subject to the automatic control, and the right pump is hardly ever called into service, but doubles the supply for emergency use.

Uniform water level; when water reaches a certain height, it is forced to return to the supply tank, by an automatic by pass, thermostatically operated.

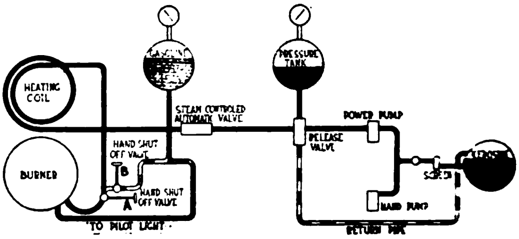


Fig. 6—Diagram of fuel system of Stanley steam car. The gasoline only supplies the pilot light which never goes out and the consumption is small, so the size of the tank is exaggerated in the cut. Kerosene, the operating fuel, is carried in the rear tank and pumped to the pressure tank from which the burner takes its supply. When the steam pressure reaches a predetermined point the supply of fuel is cut off and the kerosene pumped is allowed to go back to the main tank. The heavy black line in the cut indicates the kerosene supply, the broken black line the return lines for surplus, and the grey lining gasoline.

CHART NO. 816—The Stanley Steamer. DG—spur drive gear on engine; GD—differential gear in mesh with it: DP—differential drive pinion; DG—(lower) differential gear mesh with generator; CR—connecting —connecting rod yoke; SV—slide valve; CHG—cross head guides.

The Doble Steam Car.

How the Doble Differs from the Stanley.

1st—Doble boiler is of the water tube type. Stanley boiler is of the fire tube type.

2nd—Doble boiler consists of 28 sections, placed in an insulated casing, Stanley boiler is in reality a big drum standing over the burners.

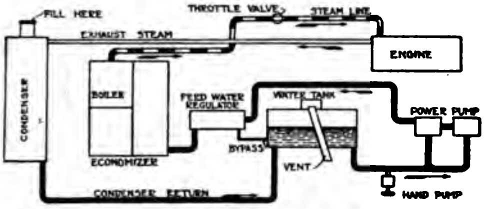


Fig. 3—Water and steam piping diagram of the Doble steam car. The cycle of operations is as follows: Water put into the condenser flows to the water tank by gravity. It is pumped by a power pump through the regulator and economizer into the boiler, where it is changed to steam. Steam from the boiler passes through the throttle into the engine, thence to the condenser, where it is reduced to water again

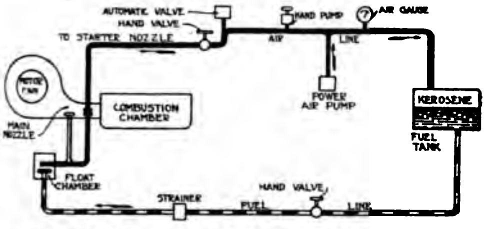


Fig. 4—Air and fuel piping: Air pressure of 2 lb. per square inch is maintained in the fuel tank. The blower motor is started through a switch, after which speed is regulated automatically by the steam pressure

3rd.—Doble has no pilot light, (mixture ignited by electric spark.) Stanley has only a pilot light for ignition.

4th—Doble uses kerosene for both starting and running. Stanley uses gasoline for starting, kerosene for running.

5th—Doble slide valve used only for admission of steam to engine cylinder. Stanley slide valve regulates both admission and exhaust.

6th—In the Doble the exhaust steam goes direct to radiator. In the Stanley the exhaust passes through a feed water heater before it goes to the radiator.

Features of the Doble.

Sectional boiler; 20 sections used for generating steam and 8 sections used for feed water heater or economizer.

Absence of pilot light: This is a radical departure from the usual construction.

Kerosene for starting; as well as for running.

Wide pistons; necessary on account of pistons having to open and close exhaust port (similar to a 2 cycle gasoline engine) and is termed the uniflow principle.

Absence of eccentrics; valve gear is a modified form of the "Joy valve gear" in which modification the "correcting" and "anchor links" are eliminated, thus simplifying the construction.

Final drive (gear ratio) is almost 1 to 1, viz: 47 teeth in drive gear and 49 in differential.

A condenser is provided so that the steam is reconverted into water—and used over and over again.

Lubricating oil is mixed with the water for lubrication of cylinders.

A Motor Bob—Wheel Drive.

Riding board 14" wide x 1¼" thick. 2—7" strips may be used, but a single plank is best. Two 1x3" pieces trengthen it. Two **running boards** hung on steel brackets offer foot rest for passengers. Sleds should be made of hard-wood with steel runners.

Engine motorcycle type. Mounted in frame of ⅝" round stock per fig. 3. Weight of bob is not carried on the wheels, therefore two heavy coil springs forces wheel to ground (fig. 1), by pull on frame.

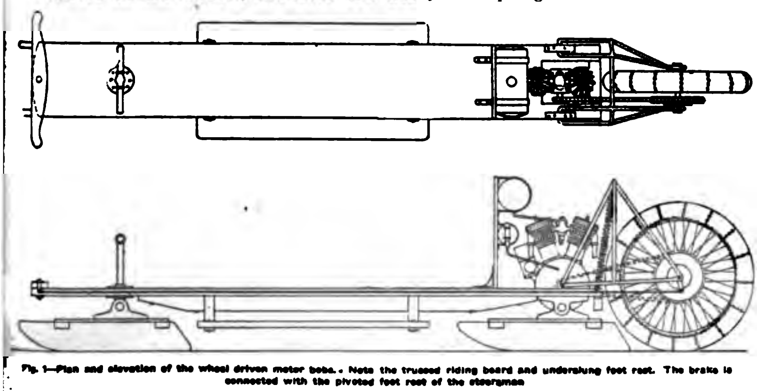
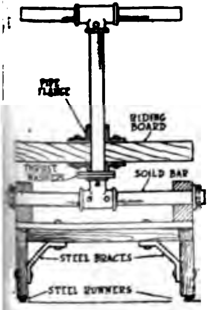


Fig. 1—Plan and elevation of the wheel driven motor bobs. Note the trussed riding board and underslung foot rest. The brake is connected with the pivoted foot rest of the steersman

Also note the skid chain on motorcycle wheel to give it traction. Steering is shown in fig. 2.

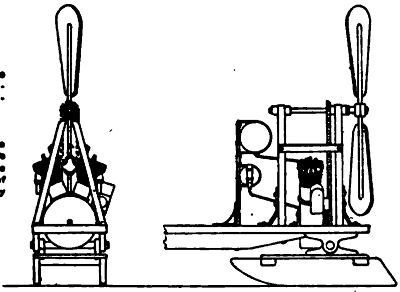
Propeller Drive

is shown in fig. 4. Not recommended for narrow gage bobs. Has advantage over the wheel in that wheel has difficulty of obtaining traction in soft snow or broken roads. Better ask some aeroplane propeller manufacturer if propeller is used, as to revolutions and size.



Left—Fig. 2—Detail of the front bob mounting, showing the steering mechanism

Right—Fig. 4—A simple method of mounting the propeller at the rear. The standards are made of 2-in angle irons, rigidly braced



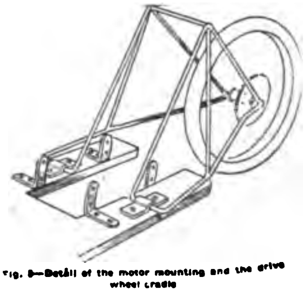
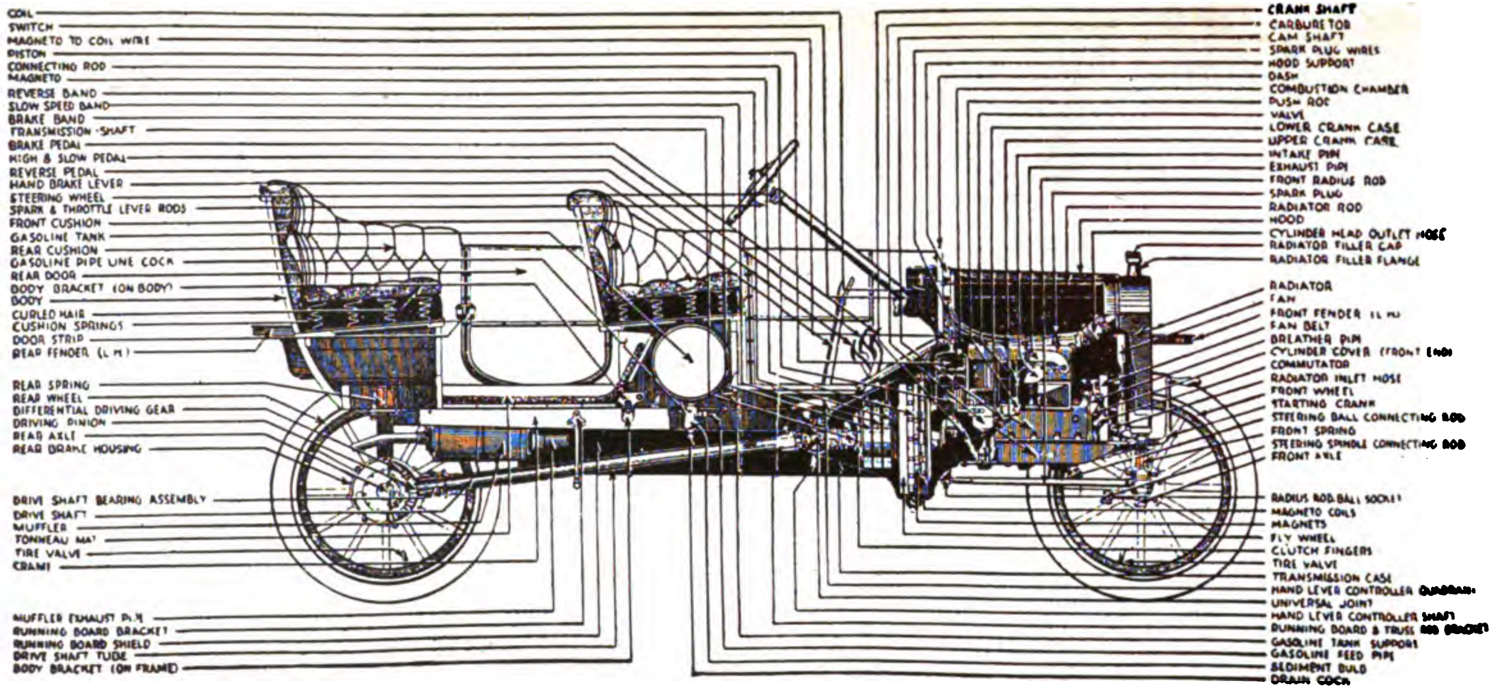


Fig. 3—Detail of the motor mounting and the drive wheel cradle

HART NO. 316A—Doble Steam Car. A Motor Bob. (Automobile.)

e Doble steam car is manufactured by the Doble-Detroit Steam Motor Car Co., Detroit, Mich. Stanley, by Stanley am Car Co., Newton, Mass.



Specifications of Ford Car.

Axles; (front) I beam drop forged from Vanadium steel. **Rear axle;** semi-floating enclosed in a tubular steel housing. **Differential,** three pinion type.

Bodies are in 5 styles; runabout, 2 passengers; touring car, 5 passengers; coupelet, 2 passengers; town car, 6 passengers; sedan, 5 passengers.

Brakes; dual system. "Running" or "service" brake on transmission controlled by the foot. "Emergency" or "hand brake" is the expanding type in drum of rear wheels. Controlled by hand lever on left side.

Clutch, multiple steel discs operating in oil. **Control**—On the left side of car. Three foot pedal controls, low and high speeds, reverse, and brake on the transmission. Hand lever (for neutral, and emergency brake) on left side of car. Spark and throttle levers directly under steering wheel.

Cooling—By thermo-syphon water system. **Lubrication;** gravity and splash, see pages 772 and 197. Oil is poured into crank case through breather pipe on front cylinder cover.

Ignition, see pages 803 and 265. **Gasoline capacity** 10 gallons.

Engine, 4 cylinder, four cycle 3¾ bore x 4 inch stroke. 22.5 S. A. E. horsepower rating. Cylinder head detachable. Cylinders enbloc. Lower half of crank case one piece pressed steel. All interior parts reached by removing plate on bottom of crank case. **Three point suspension** of power plant. **Valves** on right side of engine.

Springs, semi-elliptic.

Transmission; spur planetary gear type.

Wheels wood artillery type. **Wheel base,** 100 inches. Standard tread 56 inches. Cars will turn in 28 foot circle. **Tires** 30x3 front, 30x3½ rear, clincher type.

Later Changes on Ford.

(1) fitting of a new style radiator; (2) sloping hood; (3) crowned fenders; (4) fan with shield around it; (5) electric vibrator type horn operated from magneto; (6) speedometer bracket no longer fitted; (7) 60 inches or "Southern" tread, no longer made.

Cost of Operating a Ford.

Gasoline, 22 miles per gallon; **Lub. oil,** 400 miles per gal. Tires average 4000 to 5000 miles. City license $3. State license $3. Summing up, say for 4000 miles running would have; 182 gal. gas, at 25c, $45.50; 10 gal. oil at 50c, $5.00; license for one year $6. Tires and tubes 2, at $14 and 2 at $17. $62. This would make a total of $118. for 4000 miles. If 150 miles per week was averaged this would make a cost of $112. for 26 weeks or $18.50 per month. Washing and storage extra if kept in a garage. (**Figures approximate**).

CHART NO. 317—Sectional View of the Ford Car Showing the Names and Location of Parts.

See Insert No. 2 for half tone view of Ford power plant. See page 864-A for Ford Electric Starter.

Supplement
ON THE
FORD
(Model T)
TREATING ON
PRINCIPLE OF CONSTRUCTION, OPERATION, CARE AND REPAIR
TOGETHER WITH USEFUL AND INSTRUCTIVE
HINTS AND SUGGESTIONS.
ALSO TREATING ON FORD TRUCK, TRACTOR AND HOLLEY VAPORIZER.

INDEX TO FORD SUPPLEMENT
(See colored insert for beginning of the General Index to this Book)

A

Page
Adjusting bands ....770 to 779
  " bearings 787
  " brakes 781
  " carburetor 798
  " carburetor, fine points of 802
  " clutch fingers 776
  " coil 808
  " connecting rod 786
  " differential 781
  " fan blade 788
  " wheels 774
  " steering gear 773
Address of part manufacturers..............820
Air gap clearance of magneto...........807-864-J
Air pressure for racing 815
  " valves and priming methods 801
Alignment of crank shaft 792
Alignment of pistons 659
Alignment of wheels 774
Aluminum pistons 792
Amperage at various speeds 770
Atwater-Kent ignition 809-810
Auxiliary air valves 801
Axle straightening 782

B

Ball and socket joints 778
  " cracked 774
Bands, cause of wear 777
Band linings, size of 777
Bands, removing and replacing (transmission) 777-778
Batteries (storage) for lighting..............812
Bearings, adjusting of 787
  " of transmission 776
  " reamer 792
  " removing of 787
Bodies combination 821
Boiling water 788
Brakes 781
Brake and reverse bands, tightening of........777
  " band lining, size of 770
  " drum 780
  " fails to hold, cause of....................777
Bushings in spindle 778-792
Bushings, removing of 778-792

C

Carburetors ....798 to 799
Carburetor adjustment 798
  " adjustments, fine points of 802
  " for racing 815
  " float adjustment 798-799
  " Holley 799
  " Kingston 798
  " mixture explained 801
  " mixture control 802
  " pointers 800
  " Schebler (Pitot) principle 800
  " troubles 800
Car creeps forward, when cranking...........776
Carbon cleaning 790
Cam gear, number of teeth 770-785
C. p. of lamps (candle power)............770-812
Cam shaft for racing 814
  " shaft, removing of 788
Chamfering piston ring 793
Changes on later Fords 766
Charges for overhauling 794
Chassis 766-770
  " for commercial use 821-822
  " division into units 770
Chattering noise in transmission..............776
Cleaning carbon 790
Cleaning oil pipe 709
Cleaning radiator 789
Clearance of air gap of magnets........807-864-J
Clutch adjusting screw 776-777
  " assembly 779
  " control 776
  " dragging and slipping, cause of........776
  " in neutral 776
  " spring 779
  " spring compressor 819
  " tightening of 779
Commercial bodies 821
Commutator 805
Commutator, oiling of 772
Compression pointers 790-817
  " increasing of 798-817
  " poor 790
Commutator, removing of 804
  " troubles 804
Commercial type cars 822
Connecting rod bearings removing and adjusting 786
  " rods for racing 817
Control of car 771-777
  " movements of levers....................777
Converting Ford for commercial use.......822-828
  " Ford into 7 types of bodies.......822
Coil adjusting 808
  " box 803
  " units 808-803
  " unit defective 808
Cooling system specifications....................770
  " when racing 814
Cost of operation 766
Cranking engine 771
Crank case lower cover size cap screw........786
Crank shaft alignment 792
Crank shaft bearings 787
  " shaft, removing of 788
Cut-out and muffler 819
Cylinder, enlarging of 792-818
  " high compression 816-798
  " head bolts broken off 796
  " head cap screw, size of............788
  " head gasket, replacing of..........790
  " head, removing of 788-787
  " over lubricated 798
  " reamer 792

D

Data on Ford, condensed....................770
Dead points (magneto)....................805-265
Demountable rims and wheels....................828
Differential 781
Differential greasing of 772-782
Dimming lights 429-795-437
Disassembling rear axle 780
Dragging clutch 776
Draining oil 772
Dressing vibrator points 809
Drive shaft and housing 780
  " systems for commercial use 822
  " pinion, removal of 780
Dry cells for starting 804

Copyrighted 1917, 1918 and 1919, by A. L. Dyke, St. Louis, Mo.

Page

E

Electric lamps, votlage of.......770-812-864A-434
'' lighting 803-812-864A
'' system 803-810-811-864A
Engine, device for raising 797
'' enlarging cylinders 818
'' fails to start 800
'' firing order (Insert No. 2)..........784
'' knocks 790-800
'' lacks power 800
'' lubrication 772
'' names of parts 783-784
'' numbers, where to find 770
'' overheats 800
Engine removing from frame.........788-806-797
'' "running in" 772-798
'' sectional view 784
'' speed, miles to minutes 770
'' speed, how to tell...................823
'' specifications 770-783
'' stand 798
'' starting of 798-771
'' starting, cold weather 798
'' stops suddenly 800
'' taking down 806
'' troubles 800
'' valves, location of 783
'' when new 772
Exhaust and inlet for racing.............815-782

F

Fan blade adjustment 788
Firing order of engine 784
Firestone demountable rims and wheels.......823
Fly wheel, how connected with crank shaft.....784
Ford tractor 826
'' truck 825
'' engine in motor boat.......................825
Frame, how to lower ....816 & 815
Front axle, removing of.......................774
'' axle removing and straightening.........774
'' wheels and axle 774
'' wheels, clicking noise in 774
Frozen water, to thaw out........788-579-193-800

G

Gaskets 796
'' cylinder head, replacing of 790
'' to prevent leakage of oil.............807
Gasoline, how to save 819-802
'' tank gauge 801-823
Gauge for gasoline 801-823
Gauge for oil 782
Gears for rear axle 780-781
Gear ratios 781
Gears (timing) number of teeth..............770
'' of transmission ....775 to 779
Grease leaks from rear axle.................782
Greasing rear axle housing 772
Grinding valves 790

H

High gear ratio 770-775
Holley carburetor 799
Hose bands and hose, size of 770

I

Ignition for racing 818
'' system ....803 to 811
'' timing 804
'' troubles 808

J

Jacking up front of car 774
Jerking motion of car, one cause, glazed band lining 777

K

Kemco electric system 810
Kingston carburetor 798
Knocks of engine 800-790

L

Lamps, electric 770-812-434
Lapping rings 818
Late changes on Ford 766
Levers and pedals 777-771
Lowering frame ....816 & 815
'' front axle 816
Low gear ratio 770-775
Lighting connections 812
Lubrication for racing 816-814
'' of engine and transmission........772
Lights, how to dim..................795-429-437
Lynite pistons 792

Page

M

Magneto 805
'' amperage and voltage 770
'' assembling 806-807
'' repairing 806-807
'' terminal 805
'' tester . , ...806-864-J
Magnet poles, how placed 806
Magnets, late type 807
'' recharging of 807-819-864J
'' removed for racing 814
'' weak. cause of 805-806
'' clearance of 807-864J
Main bearings 787
Master vibrator 809
Meshing timing gears 785
Missing of explosion 808
More miles per gallon 802-819
Muffler for racing 782

N

Neutral position of lever adjustment........776
Noisy transmission gears, cause of..........776
Number of engine, where to find.............770
New York Coil Co. ignition..................810

O

Oil, draining from engine 772
'' for winter 776
'' kind to use 772
'' leakage, out rear wheels 782
'' level, testing of 772-782
'' pump for racing 816-814-810
'' pipe clogged, how to clean..............709
'' too heavy for engine 776
Oiling engine and transmission..............772
Operation and control of car 771
'' cost 776
Overhauling a Ford 794
Overhauling, charges for 794
Overhead valves for Ford 791
Overheating of engine 800
Overheating, causes and cures 788
Oversize tires 823
Oversize, engine valves 791

P

Painting radiator 789
Paints for Ford 819
Pedals and levers 777
Pistons 792
Piston clearance 813-818-792-793
Pistons, oversize 792
Piston pin bushing reamer 792
'' pumping oil 793
'' remedy for excess oil 793
'' removing of 788
'' rings 791-792-793
Pitot principle, carburetor 800
Power from rear wheels 819
'' plant 783
Prices 1912 to 1919 770
Price for overhauling Ford 794
Priming engine 771-803
Primary circuit 803
Priming methods and air valves..............801
Principle of transmission 775
Pumps for water 819
Push rods, installing 788

R

Racing body specifications 820
'' type Fords ....813 to 818
'' ratio of gearing 781
Radius rod, front 773-774
'' rod rattles 774
Radiator, cleaning of 789
'' hose 770
'' hot 788
'' leaky 789
'' painting 789
'' removing 789
'' repairing 789
'' testing 789
Raising front end of car 797
'' rear end of car 797
Ratio gearing for racing 815
'' of gearing 770-780
'' of high and low gear 770-775
Reamers 791-792
Reaming cylinders 792
Rear axle disassembly 780
'' '' and parts 780
'' '' leaks grease 782
'' '' removing of 780

*See page 864A for "**Ford Electric System**" as used on enclosed cars.

FORD INDEX—Continued.

Rear axle semi-floating 780
" " shaft, bent 780
" " " replacing of 780
" " " removing of 780
" " stand 797
" wheels 781
Relining bands 778
Remagnetizing Ford magnets 807-819-864J
Removing and replacing transmission bands 777-778
" axle shaft 780
" bearings 787
" bushings 778-792
" cam shaft 788
" carbon 790
" commutator 804
" connecting rod bearings 786
" crank shaft 788
" cylinder head 783-787
" differential 781
" driving pinion 780
" engine 783-806
" front axle 774
" main bearings 787
" pistons and connecting rods........786
" power plant 783
" radiator 789
" radius rod 774
" rear axle 780
" rear main bearing 787
" rear wheels 781
" steering wheel 778
" transmission cover 778
" transmission 776
" universal joint 780
" valve cover 786
" valves 790
Repairing starting crank 796
" radiator 789
" magneto 806-807
Reverse adjusting screw 777
Reverse gear ratio 770-775
Reversing car 771
Rivets for transmission bands 778
Running new engine 772
"Running-in" engine 793

S

Schebler (Ford) carburetor 800
Screw cutting plates 795
Seats for racer 820
Secondary circuit 808
Setting time of spark 804
Shellac 796
Size of band linings 777
" of brake lining 770
Size of bearing bolts........................787
" cap screw in cylinder head................783
" crank case cap screw 786
" of radiator hose 770
" of wires 804
Sizes of cars 770
Slipping Clutch 776
Slow speed adjusting screw 777
" speed band to tighten 777
Smoke, black, blue and grey..................800
Socket wrenches 795
Spark advance and retard 805
" and throttle control.......................771
" plugs, constantly fouled 793
" plug tests 808
" setting 804
Specifications 766-770
" of racing body 820
" of engine 783
Speed and miles per hour 770
" of car, how controlled 771
" of engine, how to tell.....................823
" of engine to car 770
Speeding up a Ford ....813 to 818
Speedometer shaft broken 819
Spindle bushings 773-792
Splitdorf electric system for Ford............828
Spokes loose 810
Spotlight bulb 812
Spring clips, keep tight 774
Spring leaves, how to remove for easy riding...774
Spring leaves added for truck use 774
Springs, care of 774
Springs for valves 790
Starting engine 771
" car 771
" crank repair 796
Steaming radiator, cause of...788-800-189-579-193,
Steering gear system 773
Stopping car 771
Storage batteries for remagnetizing...........807
Storage battery for ignition and lights....804-812
Straightening front axle 774
Stripped cylinder head bolts 796

T

Tank gauge 801-823
Taps and dies 795
Testing engine after repairing 798
" magneto coils 805-806-864J
" for a weak magneto.................864J-806
" oil level 772
" radiator 789
" spark plugs 808
" vibrator points 808
" wheels 774
Throttle control lever 771
Tightening brake and reverse bands............777
Tightening steering gear 773
Timing gears, meshing of 785
Timing gears, number of teeth 770
Tires, size of 823
Tires, transposing of 774
Tool box in door 819
Tools for Ford 795
Touring in a Ford 797
Tractor 826
Truck 825
Trailers 822
Transmission and clutch pointers 776
" assembly of 779
" bands 776-777
" band adjustment 779
" band linings worn 777
" bands, relining of 778
" band rivets 778
" bands, removing and replacing.777-778
" bearings 776
" bolts, how to put in.......................709
" bushings worn 776
" cover, replacement of 776
" disassembly of 778
" gears . ...775 to 779
" how connected with fly wheel....784
" noisy, cause of 776
" parts, name of 778-779-784
" principle of 775
" removing of 776
" removing cover 778
" special types of ... .781
" triple gears 779
Transposing tires 774
Tread 770
Triple gears 779
Troubles of engine 800
" of commutator 804
" ignition 808
" knocks 790
" of overheating 788
Truck and delivery methods 822

U

Universal joint and shaft bushing 781
Universal joint repair, remedy for excess oil...782
Useful devices 819

V

Valves and cam shaft for racing..................817
Valve adjusters 791
" clearance 785
" grinding 790
" guide reamer 791
Valves, how open and close 785
Valves, larger 814-818
Valve location on engine 783
Valves overhead for Ford 791
Valves, oversize 791
Valve refacer 791
Valve seat reamer 791
Valves, size of 791
Valve springs 790-817
Valve timing 785
Vibrator points, dressing of 809
Voltage of lamps 770-812-434
Voltage and magneto speed 770-812-823

W

Water boils 788
Water frozen and steaming.......788-579-193-800
Wheels and demountable rims 828
Wheel alignment 774
Wheel base 770
Wheels testing and adjusting of 774
Weight of car 770
Wind shield protector 823
Wiring diagrams 808
Wiring for lighting 812-808
Wires, size of 804
Wrenches, special 795

(Illustration on page 766 courtesy of "Fordowner.")

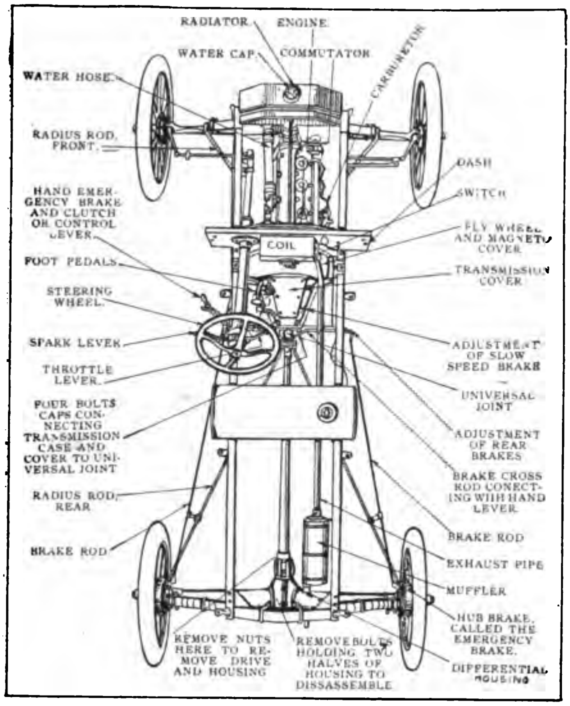

RADIATOR
ENGINE
WATER CAP
COMMUTATOR
CARBURETOR
WATER HOSE
RADIUS ROD, FRONT
HAND EMERGENCY BRAKE AND CLUTCH OR CONTROL LEVER
FOOT PEDALS
STEERING WHEEL
SPARK LEVER
THROTTLE LEVER
FOUR BOLTS CAPS CONNECTING TRANSMISSION CASE AND COVER TO UNIVERSAL JOINT
RADIUS ROD, REAR
BRAKE ROD
COIL
DASH
SWITCH
FLY WHEEL AND MAGNETO COVER
TRANSMISSION COVER
ADJUSTMENT OF SLOW SPEED BRAKE
UNIVERSAL JOINT
ADJUSTMENT OF REAR BRAKES
BRAKE CROSS ROD CONECTING WITH HAND LEVER
BRAKE ROD
EXHAUST PIPE
MUFFLER
HUB BRAKE, CALLED THE EMERGENCY BRAKE.
DIFFERENTIAL HOUSING
REMOVE NUTS HERE TO REMOVE DRIVE AND HOUSING
REMOVE BOLTS HOLDING TWO HALVES OF HOUSING TO DISSASSEMBLE

Fig. 2—Chassis.

Construction.

The Ford chassis is divided into units —such as; the front axle system; the rear axle system; the engine and transmission unit; and the dashboard, which includes the steering column. It is well to remember these units when making repairs to cars, for it often is necessary to remove the entire unit from the car when a certain part is to be repaired. For example; when repairing an axle shaft, it is necessary to remove the entire rear axle system, in order that the shaft may be taken out.

The general construction of the Ford includes triangular bracing and three-point suspension (see fig. 49, page 786). That is, most parts of the car, such as the radiator, the gasoline tank, and the power plant must be unfastened at three points, before they can be removed from the car.

The constructional details of the various parts of the car are described in the sections devoted to each unit, in this section of the book. The construction, care, and repair of the various parts are so closely related that it has been thought best to group them together.

Ford Data—Condensed.

	*1918 1919	1917	1916	1915	1914	1913
Touring ...	$525	$360	$440	$490	$550	$600
Roadster ...	500	345	390	440	500	525
Chassis	475	325	360	Not sold	Not sold	Not sold
†Coupelet ..	650	550	590	750	....	....
Town car...	750	595	640	690	740	....
Sedan	775	640	740	975	....	....

Sizes of Cars.

	Height	Width	Length
Touring ..	6 ft. 10 in.	5 ft. 8 in.	11 ft. 3 in.
Runabout .	6 ft. 10 in.	5 ft. 8 in.	11 ft. 8 in.
Town car..	7 ft. 00 in.	5 ft. 8 in.	11 ft. 3 in.
Coupelet ..	6 ft. 10 in.	5 ft. 5 in.	11 ft. 8 in.
Sedan	6 ft. 5 in.	5 ft. 5 in.	11 ft. 3 in.

Weights.

Runabout .	1405 lbs.	Engine and trans...	380 lbs.
Touring car	1500 lbs.	Runabout body ..	300 lbs.
Coupelet .	1560 lbs.	Touring body ...	415 lbs.
Sedan	1785 lbs.	Coupelet body	450 lbs.
Town car .	1785 lbs.	Sedan body	600 lbs.
Chassis ...	1100 lbs.		

Engine.

Bore 3 $\frac{3}{4}$ in.; Stroke 4 in.; Piston displacement 176.7 in.; Piston rings (3) 3$\frac{3}{4}$x$\frac{1}{4}$ in.; Valves; diameter 1$\frac{1}{2}$ in.; Valve clearance $\frac{1}{32}$ in.; Firing order 1, 2, 4, 3; Timing gears:

cam gear (see foot note, page 785)......	42 teeth
cam gear diameter	5 $\frac{1}{3}$ in.
crank shaft gear	21 teeth
crank shaft gear diameter	2 $\frac{2}{3}$ in.

‡Magneto Speed and Voltage.

200 revolutions per minute of engine, generator generates 8 volts; 300 r. p. m. 9$\frac{2}{10}$ volts; 400 r. p. m. 12$\frac{2}{10}$ V; 500 r. p. m. 14$\frac{4}{10}$ V.; 600 r. p. m. 16$\frac{4}{10}$ V.; 700 r. p. m. 18$\frac{8}{10}$ V.; 800 r. p. m. 20 V.; 900 r. p. m. 22$\frac{8}{10}$ V.; 1,000 r. p. m. 24$\frac{3}{10}$ V.; 1,200 r. p. m. 27 V.; 1,500 r. p. m. 30 V.

Amperage at 200 r. p. m., 3 amperes. At 1,500 r. p. m., 5 amperes.

‡Lamps generally used are two 8 or 9 volt, 15-c. p. lamps connected in series—this equals 16 or 18 volts.

Speed of Engine to Car.

Drive shaft pinion—bevel gear 40 teeth.

Low speed ratio, 10 to 1. High speed ratio, 3$\frac{7}{11}$ to 1. Reverse ratio, 14.5 to 1. Rear Wheels. 30".

To find the speed in miles per hour:

Eng. speed per min.	mi. per hr. reverse	mi. per hr. 1st speed	mi. per hr high speed
500	3.892+	5.589—	12.295+
600	4.761+	6.706—	14.754+
1000	7.784+	11.178—	24.590+
1500	11.676+	16.767—	36.885+

Brakes.

Brakes on hub of rear wheels have cast iron shoes, size 7$\frac{7}{8}$x$\frac{15}{16}$x$\frac{1}{8}$. Brakes controlled by side hand lever. Brake on transmission, controlled by foot.

Size of brake band lining on transmission, also on low speed drum and reverse drum—$\frac{3}{16}$ thick, 1$\frac{1}{8}$ wide, 23 in. long.

Tread and Wheel Base.

Wheel base, 100 inches. Tread, 56 inches. (60 inch, or Southern tread, is no longer made.)

Engine Numbers.

Cars are recorded by engine numbers, rather than by car numbers and the numbers of engine and car are not the same.

Year			
1912	88,900	to	171,300
1913	171,300	to	370,400
1914	370,400	to	611,100
1915	611,000	to	1,029,200
1916	1,029,200	to	1,614,600
1917	1,614,600	to	2,449,100
1918	2,449,100	to	2,831,400

These numbers may be found stamped on left-hand side of cylinder block, above inlet hose connection.

Cooling System.

14 quart capacity. Thermo syphon principle.

Radiator hose—inlet 1$\frac{3}{4}$ inch, 3 ply 2$\frac{3}{4}$" long. Outlet 2" int. dia., 4 ply 3$\frac{1}{4}$" long.

Hose bands are 2$\frac{1}{8}$" and 2$\frac{1}{2}$" inside diameter.

Horse Power.

S. A. E. rating of engine 22.5—see page 584.

HART NO. 318—Ford Chassis. General Data.

Without war tax. Price of truck $550—see page 825. ‡See page 812, foot note. †See page 864-C for prices ord Enclosed cars with Electric Starter.

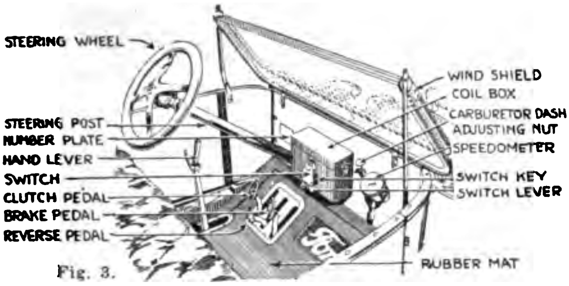


Fig. 3.

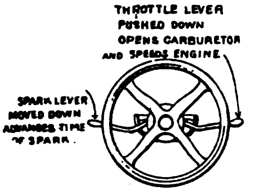


Fig. 4.

Starting Engine.

Before attempting to start the engine, see that the emergency hand brake lever is pulled **back.** This hand lever disengages the **clutch** and applies the brakes at the rear hubs, **so that** the car will not travel forward when **cranking** engine.

Be sure to retard the spark lever, that is, move the lever on the left hand side of the **steering** column, **upward,** or towards the **front** of the car, as far as it will go. (When speaking of the right or left hand side of the car, **it is** always considered that one is sitting in the driver's seat and facing forward).

The throttle lever, on the other side of the steering column, should be pulled downward about five or six notches, from the extreme **forward,** or closed position.

Now close the switch on the coil box, that is, move the switch key all the way over to the "mag." mark on the cover of the switch. If the switch key is moved over to the battery side, the engine cannot be started. The cars are not fitted with batteries, and this connection is only left on the switch, in case (at some future time) you should wish to equip your car with batteries for starting.

***Priming**: With present day grades of gasoline, it is usually necessary to prime the engine while it is being cranked. Priming shuts off some of the air, so a richer mixture of gasoline vapor is drawn into the carburetor.

This priming is done by pulling forward a small ring on the end of a wire that projects out through the radiator. This priming ring must be held out, at the same time that the engine is cranked.

Cranking engine: Grasp the starting handle firmly with the right hand, and push the starting crank in as far as it will go, feeling for the ratchets which the starting crank should engage. Hold the priming ring out with the left hand, and pull the starting crank up quickly.

The crank should be kept pushed in, while the handle is being pulled up. This requires a certain **knack**, that is soon acquired by practice. If not pushed in, the crank will slip out of the notches, and the sudden release may throw the driver off his balance.

The crank should be pulled up sharply. Slow pulls are of no value, for, unless the engine is turned over quickly, the magneto will not give enough current to make a good spark (see page 490.)

Starting the Car.

Speed up the engine a little by opening or moving the throttle lever towards you, a couple of notches. Also, advance the spark to a normal running position, about five to seven notches, from the front of the quadrant.

Place one foot on the foot brake, which is the pedal farthest to the right, so that you will always be prepared to stop and accidents may thus be prevented. Place the other foot on the clutch pedal, which is the farthest one to the left. Hold it in about mid position, that is, do not push this pedal all the way down, or let it come back all the way.

Now grasp the emergency brake lever handle with the left hand, having the palm of the hand turned towards the outside of the car and the thumb turned downward, so that the thumb can be used for disengaging the latch. This may seem awkward at first, but it is the way this lever is intended to be operated. Now, pull back on the handle,—then press latch with the thumb. It is easy to release the latch, if one pulls back on the lever first. **Now hold the steering wheel with both hands,** and push the clutch pedal forward slowly, until the car begins to move.

Gradually push the clutch pedal harder until you feel that there is no slipping in the low speed gear, and then speed up the engine so that the car is traveling at from 8 to 10 miles an hour. At the same time clutch pedal is pushed forward, push side hand lever forward as far as it will go, so that the clutch pedal may return to "high" when car is under way. The releasing of this clutch pedal engages the high speed clutch.

Let the clutch pedal come all the way back quickly, and your car will be in high gear. **Practice** will teach you how to make the change from low to high gear smoothly and easily, without jerk to the passeners or strain on the mechanism.

Reversing the Car.

Pull the emergency brake lever back just far enough to draw the clutch pedal forward and disengage the clutch, but do not pull the brake lever back far enough to engage the rear hub brakes.

Place one foot on the brake pedal, for use if necessary, and press gently on the middle, or reverse pedal. Do not attempt to drive backwards rapidly at first, for the steering is very apt to be confusing and it is not easy to drive backwards in a straight line. After the driver has become more experienced, he can reverse by holding out clutch with clutch pedal, and using low speed forward as a brake.

Stopping Car.

Partially close the throttle; release the high speed by pressing the clutch pedal forward into neutral; apply the foot brake slowly but firmly until the car comes to a dead stop.

Do not remove foot from the clutch pedal without first pulling the hand lever back to neutral position or the engine will stall.

To stop the engine, open the throttle a trifle to speed up the engine and then throw off the switch. The engine will then stop with the cylinders full of explosive gas, which will naturally make the next start easier.

Spark Control.

Left-hand lever under the steering wheel is the spark lever. Good operators drive with the spark lever advanced just as far as the engine will permit. But if the spark is advanced too far a dull knock will be heard in the engine, due to the fact that the explosion occurs before the piston has completed its compression stroke. The best results are obtained when the spark occurs just at the time that piston reaches its highest point of travel—the gas being then at its highest point of compression. The spark should only be retarded when the engine slows down on a heavy road or steep grade, but care should be exercised not to retard the spark too far, for when the spark is "late," instead of getting a powerful explosion, a slow burning of the gas, with excessive heat, will result. Learn to operate the spark as the occasion demands. The greatest economy in gasoline consumption is obtained by driving with the spark advanced sufficiently to obtain the maximum speed.

How Speed of Car is Controlled.

The different speeds required to meet road conditions are obtained by opening or closing the throttle. Practically all the running speeds needed for ordinary travel are obtained on high gear, and it is seldom necessary to use the low gear except to give the car momentum in starting. The speed of the car may be temporarily slackened in driving through crowded traffic, turning corners, etc., by "slipping the clutch," i. e., pressing the clutch pedal forward into neutral.

CHART NO. 319—Operation and Control of Car. Starting Engine.

---

*See foot note bottom of page 578 for pages referring to difficult starting. Also page 798 and 799, this instruction

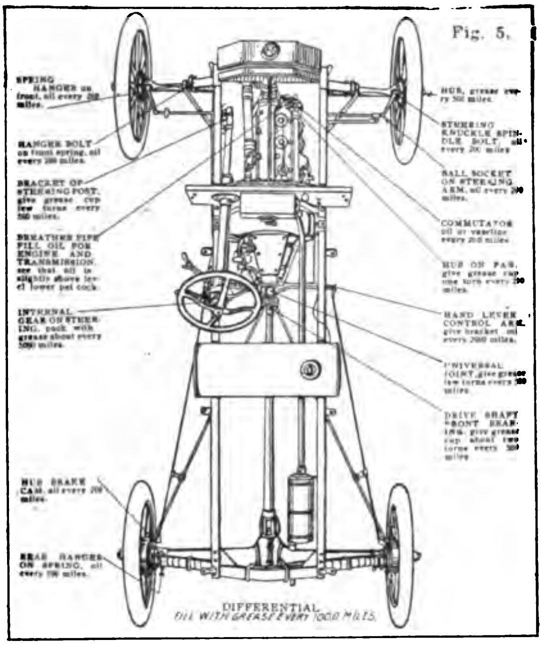

SPRING HANGER on front, oil every 200 miles.
HANGER BOLT on front spring, oil every 200 miles.
BRACKET OF STEERING POST, give grease cup few turns every 500 miles.
BREATHER PIPE FILL OIL FOR ENGINE AND TRANSMISSION, see that oil is slightly above level lower pet cock.
INTERNAL GEAR ON STEERING, pack with grease about every 5000 miles.
HUB BRAKE CAM, oil every 200 miles.
REAR HANGER ON SPRING, oil every 200 miles.
HUB, grease every 500 miles.
STEERING KNUCKLE SPINDLE BOLT, oil every 200 miles
BALL SOCKET ON STEERING ARM, oil every 200 miles.
COMMUTATOR oil or vaseline every 200 miles
HUB ON FAN, give grease cup one turn every 200 miles.
HAND LEVER CONTROL ARM, give bracket oil every 2000 miles.
UNIVERSAL JOINT, give grease few turns every 500 miles.
DRIVE SHAFT FRONT BEARING, give grease cup about two turns every 500 miles.
DIFFERENTIAL
OIL WITH GREASE EVERY 1000 MILES.

Fig. 5.

Oiling Engine and Transmission.

Oiling is most important and is taken care of by pouring oil through the breather pipe on the front end of the engine base. This pipe is covered by a metal cap, which can be easily pulled off, when oil is to be poured into the crank case. The lubrication of the engine is explained on page 197. See page 709, how to clean oil pipe.

When the engine is new: Pour in oil until it runs freely out of the upper petcock in the engine base (1, fig. 6). Be sure to close this petcock, for if it is left open, the action of the fly-wheel will splash all of the oil out through this petcock and the bearings will be ruined for lack of oil.

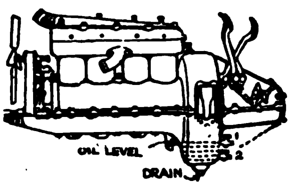


Fig. 6.

After the engine has been limbered up: The best results will be obtained by carrying the oil level about midway between the two petcocks—but under no circumstances should the oil level be allowed to get below the lower petcock.

****Testing the oil level:** If car is not fitted with an oil gauge as shown on page 782, fig. 85X, then open upper petcock. If oil does not drip out, open the lower petcock. If oil drips out, then there is enough oil for a short distance, but it is better to put more oil in if the car is to be driven a considerable distance. It is necessary at intervals to clean out these petcocks as they become clogged with dirt or sediment.

Oiling Other Parts.

This includes the filling of the different oil cups on the front axle system, the rear axle system, and the oiling of parts of the control system, which move but little. Oiling of these parts will tend to eliminate squeaks and prevent wear.

Mobilubricant; a handy grease gun containing the grease for Ford differentials and grease cups. (Vacuum Oil Co., Rochester. N. Y.)

Lubrication.

The plan view of the chassis, fig. 5, should be studied carefully, so that one will know how often the parts should receive attention and lubrication.

The oil cups can be supplied with the same kind of oil used in the engine, although a slightly heavier oil will not run away so rapidly and is better adapted to this use.

Oiling of the Commutator.

Oil is injected through the small cup on the top of the commutator shell. Engine oil is rather heavy for the oiling of the commutator and is apt to so insulate the roller from the contact points that starting may be difficult. This is especially true in winter, when the cold will so congeal a heavy oil that it will be almost impossible to obtain a good spark. "Three-in-one" oil is thin enough to be used in the commutator.

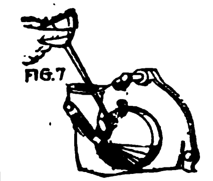


FIG. 7

Kind of Engine Oil to Use.

A light, high grade of gas engine cylinder oil is recommended. This light oil will reach into the closely fitted bearings of the engine more quickly and so less heat and friction will be developed. The oil should have sufficient body to prevent the heat and pressure in the cylinders, squeezing out the oil from between the cylinder walls and the pistons. It is expensive to use a cheap oil. Good oils save repairs to the engine, increase the mileage per gallon of gasoline, and do not form carbon nearly as rapidly as do inferior oils. In cold weather an oil that does not congeal easily at low temperatures must be used. Otherwise the clutch will drag, due to the oil acting as an adhesive. (see page 200 and 776.)

Among the oils that are recommended for the Ford engine, are Gargoyle Mobiloil "E," and White Star Extra Quality-Oil, which is used at the Ford factory.

Graphite should never be used in either the engine or the transmission, as it is apt to short-circuit the magneto and thus cause expensive repairs. (see page 205.)

Draining Out the Oil.

The new car should have the oil drained out at the end of the first five hundred miles. This also applies to an overhauled engine, when the bearings have been refitted. The oil is drained out by removing the plug at the bottom of the crankcase, and cranking the engine. The front wheels should be about six inches higher than the rear wheels, so that the oil will drain to the rear of the crank case. *Kerosene can be poured into the breather pipe, to assist in washing out the old oil, and the engine cranked to splash this kerosene over all the parts. Use at least a gallon of fresh oil, when refilling the crankcase, and be sure to replace the plug in the bottom of the crankcase tightly. If this plug drops out, the engine bearings are almost sure to be ruined for lack of oil.

Greasing.

This includes the filling of the grease cups, the universal joints and the rear axle housing with grease. Cup grease, or grease containing graphite, can be used in the grease cups, and the rear axle should not be filled too full of grease. †About 1½ pounds of grease is enough for the rear axle gears. If thrust washers are not worn, ½ lb. more can be added. A larger amount of grease will run out of the ends of the axles and spread over the wheels and tires. (see page 782, for cause of leaking oil out wheel hubs).

†Vacuum Oil Co. state that the differential housing holds 4 lbs and correct level is 2½ lbs. of Mobilubricant.

The Universal joint is one of the most important parts to keep greased.

CHART NO. 820—Lubrication.

---

*See page 201, about thoroughly draining the kerosene after cleaning.

**See pages 201, 197 and 776, "heavy oils," and page 709, how to clean oil pipe if clogged.

Steering Gear System.

The steering reduction gears are placed at the top of the steering column, instead of at the bottom (figs. 8 and 9), (as is customary on other cars). These gears increase the power, and the sensitiveness of the control over the front wheels of the car. If these gears were not used, a slight turn of the steering wheel would send the car into the ditch, while road obstructions, or bumps, would wrest the steering wheel out of the driver's control.

The lower part of steering column merely has an arm (A, fig. 9) which is connected to rod (B) extending to steering knuckle arm (SA).

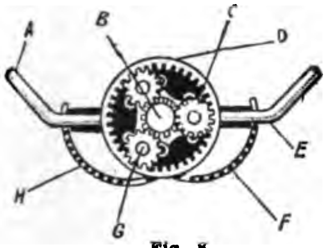


Fig. 8.

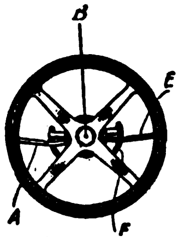


Fig. 8A.

A—Spark lever.
B—Drive pinion.
C—Pinion or gear.
D—Gear case.
E—Throttle lever.
F—Throttle quadrant.
G—Pinion pin.
H—Spark quadrant.

The steering wheel has a short shaft, on which a pinion (B) is mounted. This pinion is held in place by the cover and nut of the steering gear case. The steering rod proper, on the end is fitted with **a flange**, (triangle shape under gears) on which three studs project, which carry the three small **gears**. These **gears** mesh with the pinion, (B) and also with an internal gear cut on the inside of the steering wheel case.

To obtain access to the gears: remove the small screw, which holds the gear case cover. Then unscrew the gear case cover, and the steering wheel and the cover can be removed together as a unit. It is not necessary to remove the lower part of the steering wheel from its shaft to obtain access to the steering gears.

There are two small **retaining keys** in the top of the steering column. Keep these keys **snug**, for if loose, considerable play **will** result.

Removing Steering Wheel.

Unscrew the nut on the top of the post, and drive the wheel off the shaft, using a block of wood and a hammer. Do not batter the threads of the shaft, or it will be difficult to replace the nut.

Tightening Steering Gear.

A loose steering gear will make steering difficult and cause wear of tires. To tighten, see that the nut which holds arm (A) at lower end of steering rod (R) fig. 9, is tight.

Ball and Socket Joints.

There is a ball on the end of arm (A), which fits into a socket (C), fig. 9-B. If not kept oiled play will develop.

There is also a ball on end of thrust rod (B) which connects steering arm (SA) fig. 9-A.

If the ball and socket becomes worn from lack of oil, it can be ground by rubbing over emery cloth, or filing as per fig. 93.

Spring ball sockets are now supplied by specialty manufacturers which take up wear automatically.

Bushings in Spindles.

There are bushings in spindle arms (S) fig. 9-A, also fig. 11, chart 322. The "spindle arm bolt" works in the bushings. The bushings wear first and if worn should be replaced.

Removing bushings: Split expanding bushing removers are best for this purpose, or else bushing can be threaded and fitted with a bolt and driven out. The bushings are short and one at each end of spindle body.

New bushings should be pressed in with an arbor press or vise or carefully hammered in with a lead mallet, or wood between hammer and bushing.

After fitting, the bushings should be reamed out. Special reamers are made for this purpose—see page 792.

The bushings must fit snug so that the bolts will turn and not the bushings.

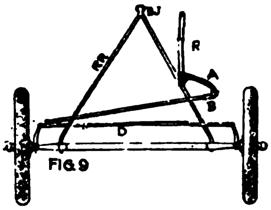


FIG 9

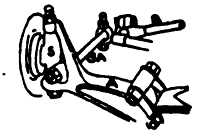


Fig. 9-A.

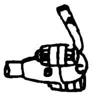


Fig. 9-B.

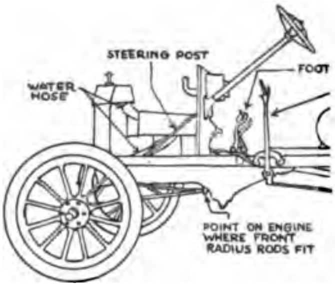


Fig. 9-C.

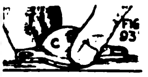


Fig. 93

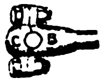


Fig. 9-E.

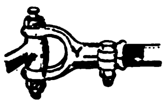


Fig. 9-D.

Fig. 9; the arm (A) is the only part connected to steering rod (B)—by means of ball and socket joint (fig. 9-B). Movement of (A) by steering rod (R) moves the front wheels. The other end of thrust rod (B) is also fitted with ball and socket joint as per fig. 9-A.

Fig. 9-C; note ball joint (BJ, fig. 9) fits in socket on engine base to support front radius rods.

Fig. 93; method of taking up wear on socket (C) which places the sockets closer together over the joint. The method is to emery the part down.

Fig. 9-D; shows the drag rod yoke (Y).

CHART 821—Steering Assembly.

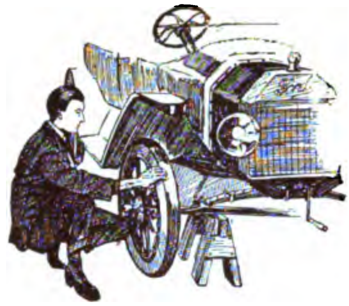
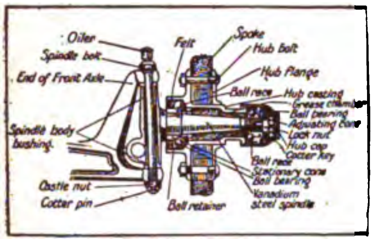


Fig. 10—Testing for play in front wheel.



Construction of front wheel bearing.

Fig. 11—Names of parts of front wheel spindle assembly. Note that the bushings do not extend entirely through the spindle body; but only at each end.

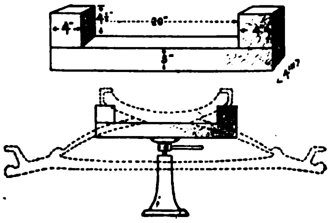


Fig 12—One method of jacking up front of car with a block of wood. The illustration shows method and dimensions. The block should be narrow enough to go between the front axle and steering connection that crosses about 4½ inches behind it.

**Front Wheels.

Removing the front wheels: Use special hub-cap wrench to remove hub-cap. Pull out the cotter pin, then take off castle nut, and lock washer. Unscrew the adjustable bearing cone. Then pull front wheel off.

The cones and castle nuts must be replaced on the spindles from which they were removed. There are left-hand threads on the left spindle and right hand threads on the other spindle. (Note—Turn top of nut towards front of car to tighten. This holds good for all wheel nuts.)

If the cones or cups are worn, they should be replaced with new parts. While slightly longer service can be obtained by turning the cones half-way around, so that the wear comes on the opposite side of the cone, this permits a certain amount of looseness and is not as good as the fitting of new parts.

If the balls are chipped, cracked, or pitted at all, they should be replaced by new ones. Chipped balls will break and ruin other parts of the bearings.

Testing the Wheels.

The front wheels should be jacked up every thousand miles or so, and tested for side play and smoothness of running. (see page 681.)

A sharp click; when running the front wheel, together with a momentary check in the motion of the wheel, indicates a broken ball, which should be immediately removed, before it causes trouble.

Adjustment.

The front wheels should be so adjusted that the wheels will come to rest—after spinning—with the tire valve at the lowest part of the wheel. Yet there should be no noticeable side play, when the spokes of the wheel are grasped with the hands and the wheel shaken as shown in figure 10.

Undue wear of the cones; may be caused by adjusting the cones so closely that the bearings bind; or to lack of lubrication. The hub-caps should be filled with a soft grease every few thousand miles.

Removing the Front Axle.

Jack up the front of the car, by supporting the frame on a couple of boxes, or by chains or ropes, or as per fig. 12. Remove both front wheels. Disconnect thrust rod (B) from arm (A) (fig. 9-A, chart 321). Disconnect the radius rod at the ball joint (per fig. 9 and 9-C, chart 321.) Remove the two spring shackle bolts at each end of the front spring.

To Disconnect the Front Radius Rod From Axle.

Remove the cotter pinned nuts. To remove the radius rod entirely—take the two nuts off the studs, which hold the ball cap, and remove the lower half of cap. (see chart 321, fig. 9, and 9-C.)

If the radius rod rattles; remove the lower half of the ball cap, and file some of the metal off the flat surfaces or rub down (as shown in fig. 93, chart 321.)

Straightening Front Axle.

In case front axle or parts are bent straighten them while cold. The application of heat will remove the effects of the heat treatment to which these parts have been subjected and will dangerously weaken them.

By bringing the point of contact of the tire and ground more nearly under the spindle body bolt, this makes steering easier and tends to prevent tire wear. (see fig. 13, and page 683).

Transposing Tires.

To use 30 by 3½ inch tires on the front wheels, a pair of rear wheels can be purchased and fitted in place of the original front wheels.

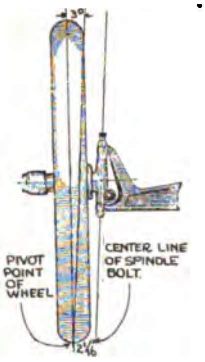


Fig. 13.

Springs.

Care of springs: If the springs seem stiff, use a screwdriver to pry the leaves apart and place some graphite grease, or heavy oil, between the leaves. (see page 622.)

Spring clips should be kept tight: If these clips are not kept tight, the strain will be put on the tie-bolt which passes through the center of the spring leaves and will break it. The tie-bolt is only intended for keeping the spring leaves from slipping out of position sideways. This is particularly true of the front spring, for if the front spring shifts sideways, it will endanger the steering of the car, and may cause an accident.

Making the Car Ride More Easily.

One or more leaves; can be removed from the rear spring of the runabout, to make the car ride more easily, **as the same spring is used on both runabout and touring cars.** The runabout does not carry so much weight. If one leaf is removed—take out the second. If several leaves are removed, take out alternate leaves, so as to maintain the general shape of the spring as nearly as possible.

For truck use; several leaves are sometimes added to increase stiffness of springs.

Alignment of Wheels.

Read on page 683, why proper alignment of wheels is necessary. The following will assist the reader in lining up the Ford wheels:

The front wheels are set at an angle of 3 degrees (1$\frac{9}{16}$ inch*); i. e., the distance between the tops of the front wheels is 3 inches greater than between the bottoms. This is to obtain ease in steering. The wheels should not, however, toe in at the front, at least not more than ¼ inch, and lines drawn along the outside of the wheels when the latter are straight in a forward position should be parallel. A plumb line dropped through the spindle bolt should strike the ground just 2$\frac{1}{16}$ inches from the pivot point of the wheel, as seen in the accompanying diagram.

Adjustment of the front wheels can be made by turning the yoke at the left end of the drag rod, drawing the wheels into a parallel position. If inspection shows that the axle or the spindles are bent it will be necessary to have those parts straightened or replaced before correct alignment can be secured.

HART NO. 322—Front Wheels and Axle. Alignment of Wheels.

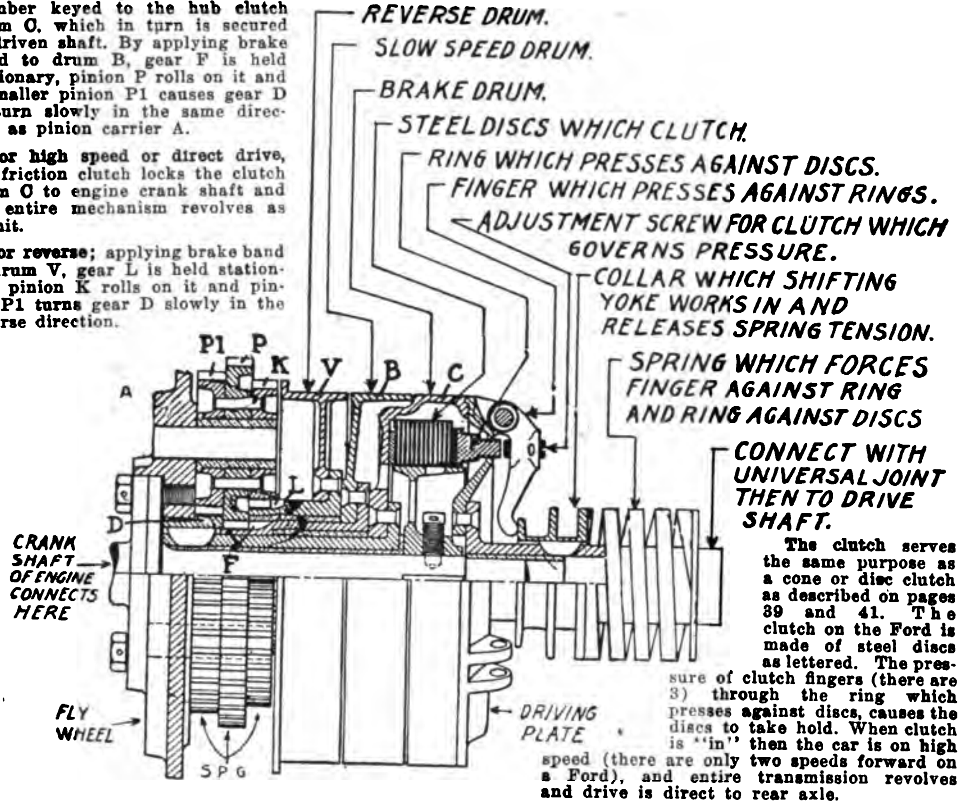
---

*See page 115 for tables "Converting degrees into inches" and "hundredths into 64th." **Timken roller bear-ngs now used on Sedan, Coupes and Trucks.

Low speed; gear D is driven member keyed to the hub clutch drum C, which in turn is secured to driven shaft. By applying brake band to drum B, gear F is held stationary, pinion P rolls on it and a smaller pinion P1 causes gear D to turn slowly in the same direction as pinion carrier A.

For high speed or direct drive, the friction clutch locks the clutch drum C to engine crank shaft and the entire mechanism revolves as a unit.

For reverse; applying brake band to drum V, gear L is held stationary, pinion K rolls on it and pinion P1 turns gear D slowly in the reverse direction.


REVERSE DRUM.
SLOW SPEED DRUM.
BRAKE DRUM.
STEEL DISCS WHICH CLUTCH.
RING WHICH PRESSES AGAINST DISCS.
FINGER WHICH PRESSES AGAINST RINGS.
ADJUSTMENT SCREW FOR CLUTCH WHICH GOVERNS PRESSURE.
COLLAR WHICH SHIFTING YOKE WORKS IN AND RELEASES SPRING TENSION.
SPRING WHICH FORCES FINGER AGAINST RING AND RING AGAINST DISCS
CONNECT WITH UNIVERSAL JOINT THEN TO DRIVE SHAFT.
P1
P
K
V
B
C
A
L
D
F
CRANK SHAFT OF ENGINE CONNECTS HERE
FLY WHEEL
SPG
DRIVING PLATE

The clutch serves the same purpose as a cone or disc clutch as described on pages 39 and 41. The clutch on the Ford is made of steel discs as lettered. The pressure of clutch fingers (there are 3) through the ring which presses against discs, causes the discs to take hold. When clutch is "in" then the car is on high speed (there are only two speeds forward on a Ford), and entire transmission revolves and drive is direct to rear axle.

Principle of the Ford Transmission.

This transmission serves the same purpose as a sliding gear or selective type of transmission as explained on page 46.

It is mounted on a shaft (F) which has a flange projection at one end, which bolts to fly wheel and fly wheel is bolted to a flange on end of crank shaft.

The planetary gears are shown as marked, (PI, P, K, & S, P, G). These gears are mounted on studs projecting from fly wheel.

By means of bands, which are tightened around the drums, the rotation of these gears are governed as explained.

It is called a planetary transmission, from a fancied resemblance between the motion of the triple gears around the central shaft and the motion of the planets around the sun.

Principle: One can work out the action of these transmision gears most easily by taking a few coins, or washers. Place one coin in the center and the three around it touching the central coin.

When the central coin is revolved, it will be found that the three others are revolved in the opposite direction.

Now, if we place a second coin of smaller size over the central coin and three other coins of larger size over the three outside coins, we can show the principle of the low speed gears.

By revolving the small central coin it will tend to revolve the three larger outside coins. As these three coins are supposed to be connected to the three coins beneath them, these three lower coins will tend to revolve the lower central coin, but at a much lower rate of speed.

The reverse gearing operates on the same general principle, except that an additional pair of gears is used, which causes the direction of rotation to be reversed.

When in high gear, the gear ratio of the car is 3.63 to 1, because the bevel drive gear in the rear axle is so much larger than the pinion that the engine makes 3.63 revolutions for every turn of the rear wheels.

When the low gear is engaged the ratio in the transmission is 2.75 to 1. This is multiplied by the rear axle reduction; so the total gear ratio, when in low gear, is 2.75 times 3.63, equals 9.98, or practically 10 to 1.

In general, owing to frictional losses in the transmission, and other causes, it may be assumed that the car will travel about three times as fast in high gear as in low. But the car will have about twice as much power when low gear is used.

When reverse gear is used the ratio is 4 to 1. The ratio to the wheels is 4 times 3.63, or 14.52, or, say, abount 15 to 1. But owing to the number of gears transmitting the power when reverse is used the actual available power in reverse is not as great as might be supposed. However, it is sometimes possible to use the reverse gear to pull the car out of a mudhole when even the low speed gear does not have sufficient power.

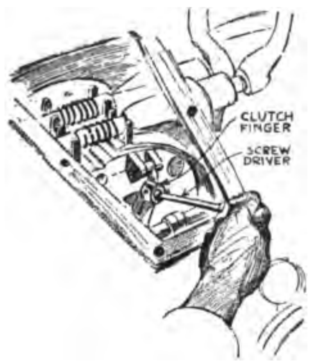


Fig. 15: Adjusting clutch fingers. Jack one rear wheel up, turn engine so clutch fingers come in convenient position, remove split-pin, give half a turn clockwise to the screw, and replace pin. Don't drop pins in transmission case. After long wear, new discs will be needed. It will be necessary to remove the transmission cover.

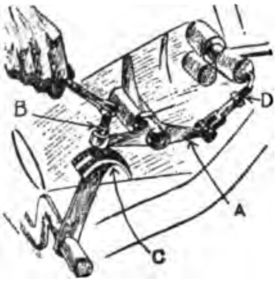


Fig. 15A: Tightening screw B to hold clutch in neutral position—see also fig. 18.

Clutch Control.

Is by the left pedal at the driver's feet. If the clutch pedal, when pushed forward into slow speed, has a tendency to stick and not to come back readily into high, tighten up the slow speed band as directed.

Should the machine have an inclination to creep forward when cranking, it indicates that the clutch lever screw (B), which bears on the clutch lever cam (C) has worn, and requires an extra turn to hold the clutch in neutral position.

When the clutch is released by pulling back the hand lever the pedal should move forward a distance of 1¾″ in passing from high speed to neutral. See that the hub brake shoe and connections are in proper order so that the brake will act sufficiently to prevent the car creeping very far ahead. **Also** be sure the slow speed band does not bind on account of being adjusted too tight.

Clutch Slips or Drags.

Slipping clutch may be due to worn main bearings, allowing crankshaft to vibrate, or to use of heavy oil in engine.

When clutch drags: This may be due to heavy or old oil. This oil collects between the clutch plates, and does not allow them to separate freely from each other, as they should, when the clutch is disengaged. An oil that is too heavy for the clutch plates, is also too heavy for good use in the engine. Heavy oil will not penetrate into the closely fitted bearings, and if the oil does not get in, friction and rapid wear will result.

Heavy oils are sometimes used in Ford engines with the idea that the heavy oil will seal the gaps between worn pistons and cylinder walls, but the only effective remedy is to replace pistons and other worn parts as needed. **In winter oil should have a low cold test,** that is, the oil should not congeal easily. It it does, the engine will be very hard to start on account of the **dragging of the clutch and the bands on the transmission drums.**

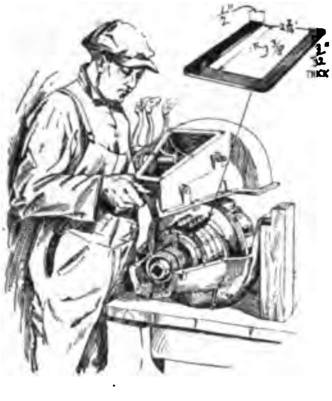


Fig. 16: This clamp is used to hold transmission bands together while replacing the transmission cover. It is made of spring steel ⅛ in. wide and 3/32 in. thick, bent into the form of a U, having legs 8⅜ in. long and being 2 7/16 in. across. One of these is clamped over the lugs on the transmission bands before replacing the cover and removed after the cover is bolted on. (Motor World.)

Transmission Gears.

If teeth of triple gears are worn or chipped, to such an extent that they do not properly mesh, they will cause a growling or grinding noise; especially when low or reverse gears are used.

Transmission Bearings.

The transmission is supported at the rear end by a babbitt lined bearing at the universal ball cap. **If this bearing is worn** it will cause a knock in the transmission when the car is traveling over rough roads.

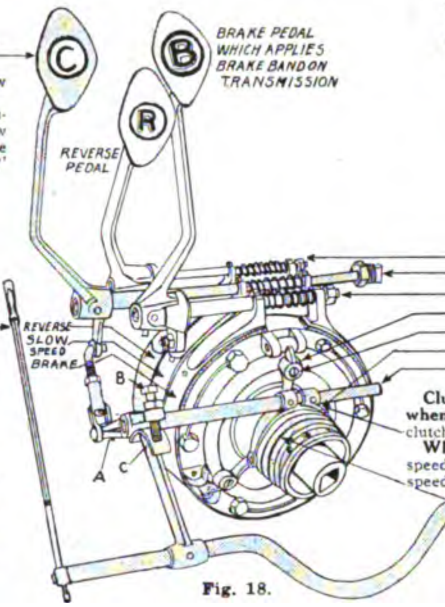
Worn bushings in the second speed and reverse drums, throws the transmission shaft out of line, hence the gears become worn and noisy. It is advisable to install new bushings as soon as worn and that before they cause gear teeth trouble, which means an ugly grinding noise.

A "chattering" noise in transmission means that new band linings are needed. The same remedy applies when car runs with a jerky movement.

To Remove Transmission.

Take the upper part of engine off the lower part of crankcase, as explained under "removing power plant," (chart 330). Next remove the **transmission cover (fig. 16), and** crankcase cover. Then the four cap screws that hold **the fly wheel to crankshaft flange,** using special Ford flywheel cap screw wrench No. 1929. The entire transmission may be then easily removed from the cylinder block **assembly.**

CHART NO. 324—Transmission and Clutch Pointers.



CLUTCH AND SLOW SPEED FOOT PEDAL.

Full forward position, "low speed" band is tightened.

Half way forward, is neutral, when in this position throw hand lever forward, release clutch pedal and "high speed" clutch is engaged.

Fig. 18: Connection of hand lever and foot pedals to transmission.

SIDE HAND LEVER

Center Vertical Position, holds clutch "out" by screw B, being on top of oval eccentric C, thereby forcing fork against spring, releasing tension against clutch discs.

Forward Position, as now illustrated, spring tension is released and on "high speed."

Back Position, spring tension is released and "brake" bands on hubs of rear wheels applied.

Clutch and slow speed lever when pushed back part of way, clutch yoke releases spring tension; **When pushed full back,** "slow speed" band is tightened and "slow speed" gears engaged.

Spring which forces fingers on clutch, to discs, unless held out by clutch pedal or side lever.

Fig. 18.

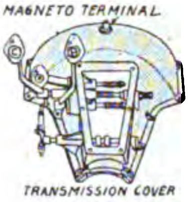


Fig. 18A.

Causes and Symptoms of Worn Transmission Band Linings.

Cause: When starting the car, the driver should press the pedal forward until the low speed begins to engage. Then the pedal should be pressed more slowly until there is no slipping of the band on the drum. When using the low speed gear on long, steep hills many drivers unconsciously relax the pressure on the pedal, so that the drums slip and wear the bands. Hold the pedals in firmly when the gears have once been engaged.

Another cause of rapid wear of the bands is the habit of some drivers of racing the engine at high speeds before attempting to engage the transmission bands. The best driver is the one who can use the gears and not speed up the engine any faster than will just avoid stalling. If the engine is not raced too fast there will not be so much difference between the speed of the transmission bands and the speed of the drums. Then there will be less wear on the band linings and less strain on all parts of the car.

When the transmission band linings have become hard and glazed they will not grip the drums until the pedals have been pushed very hard and all the oil has been squeezed from between the bands and the drums. Then the bands take hold with a series of jerks and this causes a chattering and severe strains on both the transmission and the rear axle assembly.

Other evidences of worn transmision bands are; (1) the failure of the foot brake to hold in spite of all the adjustment that can be made through the cover on the top of the transmission case, without causing the bands to drag. (2) or if the low speed and reverse gears slip when the pedals are pushed, and the engine races, while the car does not travel as fast as it should.

On an average, the brake linings should give good service for about six months; with good driving, from ten months to a year of service may be had, counting on from five to ten thousand miles driving as a year of service. (Fordowner.)

By driving on throttle, as much as possible instead of using the clutch so often, the bands will wear longer.

To Tighten Brake and Reverse Bands.

*Remove the transmission case cover and turn the adjusting nuts on the shafts to the right. (fig. 18A.)

The bands should not drag on the drums when disengaged, as they have a tendency to exert a brake effect, and overheat the engine. The foot brake should be adjusted however, so that a sudden pressure will stop the car immediately, or slide the rear wheels in emergency cases.

To Tighten Slow Speed Band.

Loosen the lock nut at the right side of the transmission cover, and turn the adjusting screw (see fig. 18) to the right.

Size of Band Linings.

All three band linings are the same size. Thickness, 5/16 inch; width, 1⅛ inch; and length, 23 inches.

---

*See page 778, how to remove transmision cover.

CHART NO. 325—Transmission Parts and Location.

Removing Transmission Cover.

(1) Remove magneto wire.

(2) Loosen the nuts on the studs of the clamps which hold the exhaust manifold in place.

(3) Pull manifold and exhaust pipe out of muffler and remove them from car—save the gaskets.

(4) Remove the ⅝ inch bolts holding on the transmission cover. (Use L-handle wrench No. 2322 for keeping nuts from turning, while the bolts are turned from below, by using T-wrench No. 2320.)

(5) Loosen and remove the two bolts which hold the universal ball cap to the transmission cover.

(6) Loosen lock nut on low speed screw and loosen low speed adjustment.

(7) Push emergency brake lever forward.

If cover is hard to remove, then loosen nuts on reverse and brake adjustment nut as far as they will go and remove the slow speed adjusting screw.

Removing Bands.

Now cover can be pulled off, and then the bands.

Place band nearest the flywheel over the first of the triple gears. Turn the band around so that opening faces downward. Band can then be removed by lifting up.

If three sets of triple gears are so placed that one set is about ten degrees to the right of center at top, the operation is considerably simplified. Each band is removed in the same way. It is important to shove each band forward on to the triple gears—as at this point there is only sufficient clearance in the crank case to allow the ears of the transmission bands to be turned down.

Relining Bands.

Instructions for relining brake bands are given on pages 688 to 690.

Never use linings containing metallic reinforcements for the transmission bands. Special Ford linings should be used. Particles of wire, worn from ordinary band linings, are apt to cut through the insulation of the magneto, which is in the same compartment as the transmission. A short circuited magneto necessitates pulling the engine out of the car for repairing.

At the Ford branches or agencies, transmission bands can be exchanged for 40 cents each. As the cost of the linings and rivets is about 30 cents, it usually pays to exchange the bands.

Use soft brass rivets: When relining the transmission bands use soft brass rivets. If iron rivets are used, particles of iron, worn from the rivets, will be attracted to the magneto, and will tend to cause short circuits.

Iron rivets are so hard that they will cut and score the soft iron brake drums, thus making them liable to break.

To Install Bands.

Simply follow the reverse of the procedure of removing the bands. When the three bands are placed in an upright position on the drums, the ease of placing transmission cover on can be facilitated by passing a cord around the ears of the three bands, holding them in the center—the pedal shafts can then be made to rest in the notches in the band ears. The clutch release ring should also be placed in the rear groove of the clutch shaft.

Replacing Transmission Cover.

First—tie the lugs of the three bands together tight, with a piece of wire or cord—or construct a band holder as shown in fig. 16, page 776.

Second; make sure that all the gaskets are in place and that none of them are defective. Broken gaskets will allow oil to escape, when the engine is running. The oil is splashed around in the transmission case by the flywheel and transmission drums.

Third; loosen the nuts on the brake and slow speed studs as far as they will go, without danger of falling off.

Fourth; compress the springs on these operating studs. This will make it much easier to replace the transmission cover.

Fifth; replace cover and all the bolts, and tighten them securely. It is not usually necessary to fit those around the sides with cotter pins. However, the bolts holding the universal ball cap must endure greater strains, so they should be fitted with cotter pins.

Remove the cord or wire, which were used to hold the bands in place while the cover was being installed.

Adjusting Bands.

Adjust bands so that the pedals can be pushed down to within a couple of inches of the floor boards, before the bands grip tightly. After running a couple of hundred miles, adjust the bands again, use double end wrench, No. 1917.

Explanation of Transmission.

Illustration on next page explains the relation of one part of the transmission to the other—as does also the illustration on page 775.

Figures 19 to 19G illustrate the parts of the transmission separated, but in their respective order to be assembled.

Clutch; note the 12 small clutch disks or thrust plates (20D) and the 13 large disks (20E), are placed together alternately (see 19B).

The projection on small plates fit slots of disk-drum (19C). The latter being rigidly fastened to transmission shaft (TS), whereas the slots in large plates fit in projections (LPP) of illustration 20A. The disk-drum (19C) is fastened to transmission shaft by set-screw (S). The pressure of the "clutch push ring" (19A) due to the tension of "clutch spring" (19) against "clutch fingers," causes the large and small disks to grasp. The adjustment of clutch fingers is made by screws (AS).

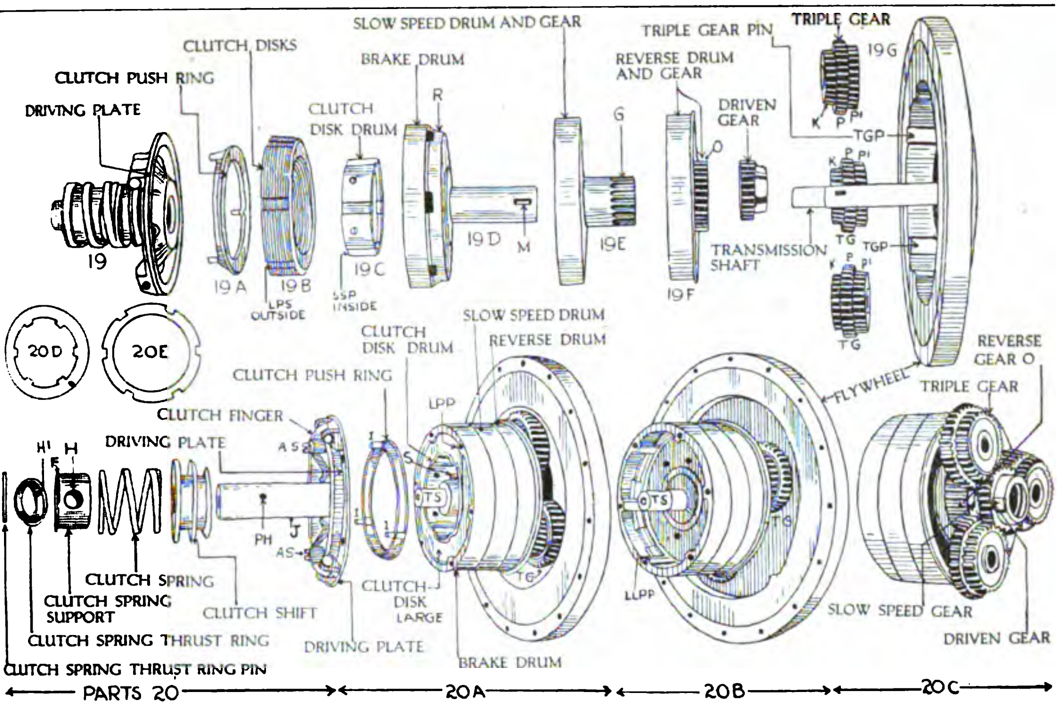
Transmission shaft (TS) and small plates (20D) run free in brake drum, when clutch is disengaged, in other words the small plates revolve with flywheel.

Slow speed drum (19E) fits over the part (R) of brake drum (19D). Driven gear is fastened to hollow shaft (M) of brake drum (19D) by means of two Woodruff keys.

Triple gears (TG); (K) are the reverse gears, (P) the slow speed gears, and (P^1) the driving gears. These gears are fastened rigidly together in groups of 3 and are called triple gears on that account. There are 3 groups and they revolve freely on pins (TGP) of fly wheel. K—meshes with gear on reverse drum (19F); P—with gear (G) on hollow shaft of slow speed drum 19E; P^1—meshes with driven gear, and is keyed to hollow shaft (M) on brake drum 19D, which projects past gear G.

The action can now be studied by referring to this illustration and page 775.

CHART NO. 326—Removing and Replacing Transmission Cover and Bands.



How to Assemble the Transmission.

First—assemble the group of parts as shown in 20C as follows; place the brake drum (19D) so that hub is in a vertical position—place the slow speed drum (19E), with gear (G) up, over the shaft (M) of brake drum. The slow speed drum will then fit over (R).

Next, place the reverse drum (19F) over the hollow shaft of (19E) so that the reverse gear (O) on drum surrounds the slow speed gear (G).

Then fit two Woodruff keys in the shaft of slow speed drum at (M) and place the "driven gear" (with teeth down) so that they will then come next to the slow speed gear (G).

Triple gears (TG) (all 3 groups); should now be meshed with the driven gear, according to the punch marks on the teeth—the reverse gear or smallest of the triple gear assembly being down.

When the triple gears are properly meshed, tie them in place with a string or cord passed around the outside of the three triple gears.

Second—assemble parts to fly wheel per 20B; place fly wheel on bench with face down, and shaft vertical.

Turn the group (20C) up side down, and place over the transmission shaft—so that the three triple gear pins (TGP) on fly wheel will pass through the triple gears.

This will now leave the brake drum on top, as shown in 20B, ready to take clutch disks (19B).

Fitting the Clutch.

Third—fit the clutch disk drum key in the transmission shaft; press the clutch disk drum (19C) over the transmission shaft (TS) (20B), and put set screw (S) in place to hold the drum.

Put a large clutch disk (20E) over the clutch drum, then a small clutch disk (20D) alternating with large and small disks until the 12 small and 13 large disks are in place—a large clutch disk—or "thrust plate" as it is termed, will then be on top as shown at (20A). Don't put a small disk on top.

Now place the "clutch push ring" (19A) over the clutch drum, so it will be on top of the disks—with the pins (1) up.

Fourth—group 20; next bolt the "driving plate" in such a manner that the adjusting screws of the three "clutch fingers" will press against the "clutch push ring pins" (1).

Fifth—it is now advisable to test by moving the clutch disks, and see if they will move freely by hand. If properly assembled, the fly wheel will revolve freely while holding any of the drums stationary.

Sixth—assemble the clutch spring parts. Place "clutch shift" (parts 20), over the driving plate hub (J), so that the small end rests on the clutch fingers. The clutch spring support is then slipped into the spring so that the flange (F) will rest on the upper coil of the spring, then insert "clutch spring thrust ring"* and press same into place. Insert the pin in the driving plate hub at PH, through the hole (H¹) in the side of the thrust ring. This part of the work requires some "knack" but is simplified considerably by using a compressor similar to that shown on page 819. The large holes (H) in clutch spring support facilitate the insertion of the pin.

Another easy method of compressing the clutch spring, so that the pin can be inserted, is to loosen the tension of the three clutch finger adjusting screws (AS).

When the clutch is tightened up again, the spring should be compressed to within a space of 2 or 2 1/16" to make sure the clutch spring does not slip.

The adjusting screws (AS) should be adjusted so that there is even tension all around the clutch disks. These screws are now provided with a slot and it is necessary to turn them at least 1 revolution so that the slot comes in line with the cotter pin holes, then insert the cotter pins.

CHART NO. 326A—Assembly of the Transmission and Clutch.

---

*On the new cars "clutch spring thrust ring" is not used, its function being incorporated in "clutch spring port" the inner end of which is contracted and has 4 small lugs for the reception of the "thrust ring pin."

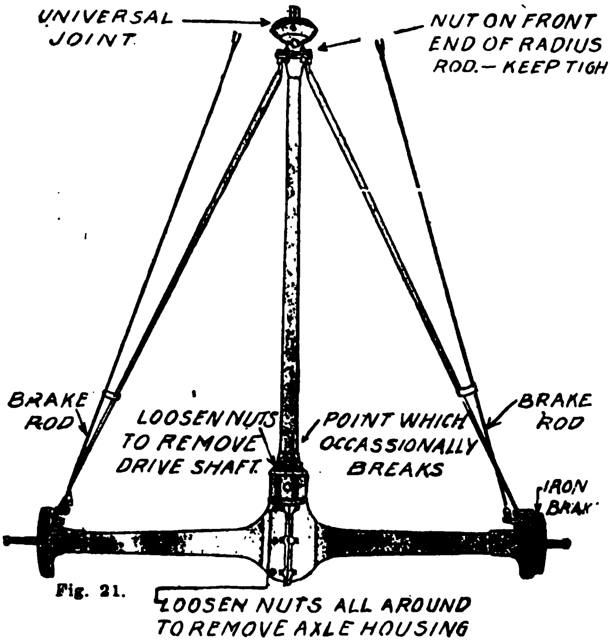

UNIVERSAL JOINT
NUT ON FRONT END OF RADIUS ROD.—KEEP TIGHT.
BRAKE ROD
LOOSEN NUTS TO REMOVE DRIVE SHAFT
POINT WHICH OCCASSIONALLY BREAKS
BRAKE ROD
IRON BRAK
LOOSEN NUTS ALL AROUND TO REMOVE AXLE HOUSING

Fig. 21.

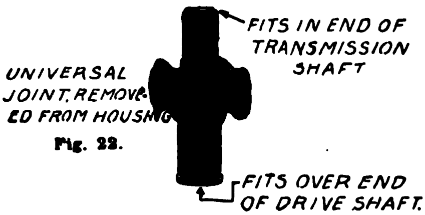
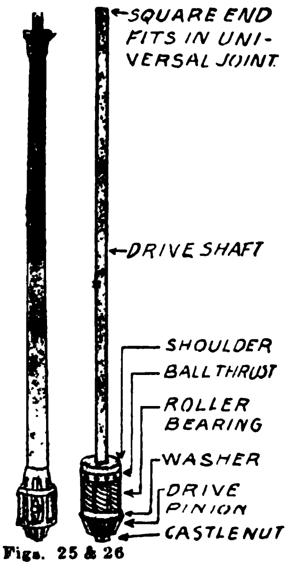

FITS IN END OF TRANSMISSION SHAFT
UNIVERSAL JOINT, REMOVED FROM HOUSING
FITS OVER END OF DRIVE SHAFT.

Fig. 22.



Figs. 25 & 26

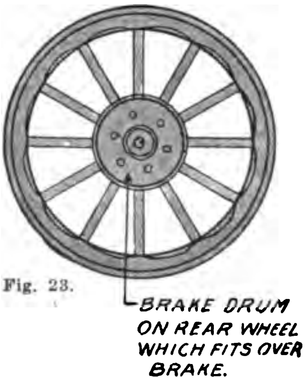


Fig. 23.

Fig. 27 — Special gears for trucks and racing. (see page 781; "Gear Ratios.")

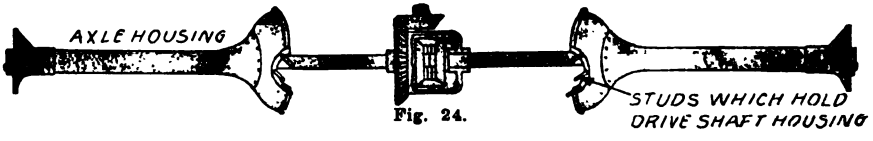


Fig. 24.

Rear Axle and Parts.

The axle housing is made in two parts, (fig. 24.) The later types of rear axle housings are much stronger than those made in earlier years.

Drive shaft and housing (fig. 25.) The housing or tubing, encloses the drive shaft and also takes the torque or twist off the rear axle, when the car is being started or stopped. This sometimes causes the tube to break, near the rear axle.

Drive shaft and its bearings (fig. 26.) There is a roller bearing to support the shaft and pinion, and a ball thrust bearing above the roller bearing to take the thrust of the pinion against the drive gear.

The entire rear axle and drive shaft, per fig. 24—must be removed when repairs are to be made to differential, drive gears, or new axle shaft installed.

To Remove Rear Axle.

Jack up car and remove rear wheels (see chart 328). Take out 4 bolts connecting unniversal bolt cap to transmission case. Then disconnect brake rods. Remove nuts holding spring perches to rear axle housing flanges. Raise frame at rear and remove entire axle. (see fig. 21.)

Disconnecting Universal Joint.

The two plugs from top and bottom of ball casting must be removed, then turn shaft until pin comes opposite hole. Drive out pin and force joint away from shaft. (see fig. 30.)

To Disassemble Rear Axle.

See fig. 21 and 24. Disconnect universal joint first, then radius rods, then loosen nuts on studs holding drive shaft to rear axle (fig. 21.) Next, remove the nuts holding the axle housing together over differential as per fig. 24. The axle housing, in two parts is then removed from axle shafts.

To Remove Axle Shafts.

Follow the plan in preceding paragraph, and as per fig. 21 and 24. Take the inner part of differential casing apart and draw axle shaft through casing at the center.

When replacing axle shaft be sure rear wheels are firmly wedged on at outer end and key in proper position. With a new car the hub caps should be removed and lock nut tightened, in fact it is essential that rear wheels be kept tight.

If rear axle or wheel is sprung by skidding or striking a curb, or if axle shaft is bent—replace at once.

Removing Drive Pinion.

The pinion end of the drive shaft, to which the pinion is attached, is tapered to fit the pinion tapered hole which is keyed onto the shaft, and then additionally secured by a cotter-pinned "castellated" nut. Remove the castle nut, and drive the pinion off. (fig. 25 and 26.)

No adjustment is provided. Fit new parts if worn.

CHART NO. 327—Rear Axle. Special Gear Ratios.

—Rear axle is a semi-floating type and it is necessary to remove entire axle assembly and then the housing er fig. 24), to reach differential and drive gears. (see also page 669.)

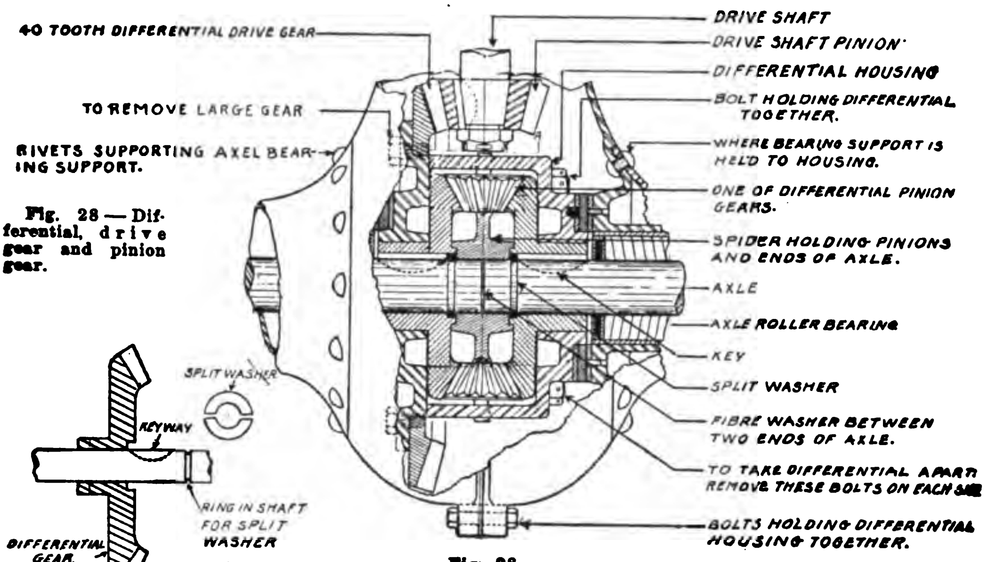

40 TOOTH DIFFERENTIAL DRIVE GEAR
TO REMOVE LARGE GEAR
RIVETS SUPPORTING AXEL BEARING SUPPORT.
DRIVE SHAFT
DRIVE SHAFT PINION
DIFFERENTIAL HOUSING
BOLT HOLDING DIFFERENTIAL TOGETHER.
WHERE BEARING SUPPORT IS HELD TO HOUSING.
ONE OF DIFFERENTIAL PINION GEARS.
SPIDER HOLDING PINIONS AND ENDS OF AXLE.
AXLE
AXLE ROLLER BEARING
KEY
SPLIT WASHER
FIBRE WASHER BETWEEN TWO ENDS OF AXLE.
TO TAKE DIFFERENTIAL APART REMOVE THESE BOLTS ON EACH SIDE
BOLTS HOLDING DIFFERENTIAL HOUSING TOGETHER.
SPLIT WASHER
KEYWAY
RING IN SHAFT FOR SPLIT WASHER
DIFFERENTIAL GEAR.

Fig. 28 — Differential, drive gear and pinion gear.

Fig. 28.

The Differential.

The principle of a differential is explained on page 85. There is no adjustment on the Ford differential between the pinion and drive gear. New parts are usually fitted.

Removing differential gears: The gears are keyed on to the axle shafts and held in position by a ring or split washer, which is in two halves and fits in a groove in the rear axle shaft. (see fig. 96, page 782.)

Force them down on the shaft, away from the end to which they are secured, drive out the two halves of ring in the grooves in shaft with screw driver or chisel, then the gears can be forced off the end of the shafts.

Rear Wheels.

Are fitted with pressed steel brake drums to which the emergency or hand brake operates. See fig. 29, 28 and 21.

To remove rear wheels take off hub cap, remove cotter pin, unscrew nut and with a wheel puller remove wheel from tapered shaft to which it is locked with a key.

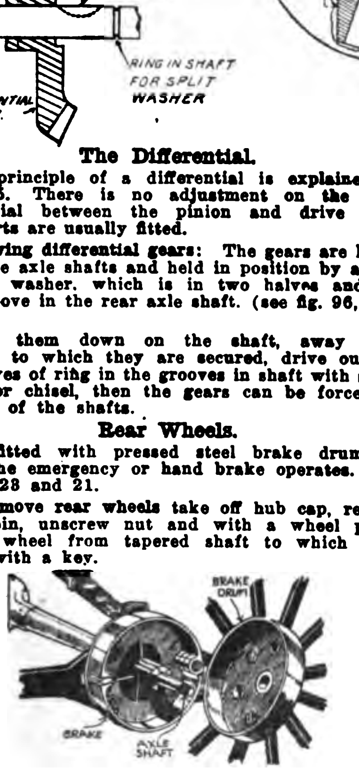


Fig. 29.

Brakes.

Fig. 29. The cast iron brake shoes will wear if used very much. This brake is usually used for holding car when at rest on an incline and not for slowing down car.

Brake shoes, lined with asbestos fabric can be obtained from accessory dealers and will last longer than plain cast iron shoes.

To replace these brake shoes, (1) remove the rear wheels; (2) unscrew nut and bolt on which the brake shoes are pivoted to the axle housing. Brake shoes can now be pulled off.

Put springs in place on new brake shoes; then place open ends of brake shoes over the cams, and swing brake shoes into place.

Replace wheels, and tighten the axle shaft nuts securely, before putting the cotter pins in place.

Equalize the rear hub brakes, by removing cotter pins and pulling out the clevis pins (see fig. 33, chart 829) and then turning the clevises on the brake connecting rods until the two brakes grip equally. Be sure that the clevises catch enough threads on the brake rods to give strength.

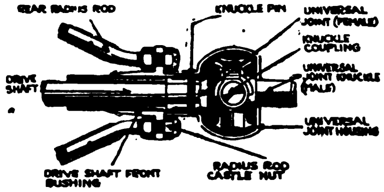


Fig. 30.

Universal Joint and Shaft Bushing.

Fig. 30. The universal joint and the driving shaft front bushing. When this bushing becomes worn, (which will take a long time, if the grease cup is turned regularly) it will be necessary to have the new bushing forced in at a Ford repair shop and then reamed to fit the axle shaft. This is a machinists job.

A Special Transmission.

A two speed rear axle is made for Fords by specialty concerns, which is useful for one-ton truck work. This gives 4 speeds. The third speed can be used on steep hills without holding foot on low speed pedal. (Woodword Truck Att. Co., Los Angeles, Calf.)

*Gear Ratios.

The standard ratio is 3 7/11 to 1. Changes can be made by purchasing the gears, fig. 27, from Detroit Radiator Specialty Co., Detroit Michigan. It is necessary to change both drive gear and pinion.

For racing use 2½ to 1; **Fast roadsters** use 2¾ to 1; **General use** for level country use 3 to 1; **General use**; average country use 3 7/11 to 1; **Trucks,** use 4 to 1.

For racing on dirt tracks where a quick pick up is required, the 3 to 1 is recommended. The 2¾ to 1 and 3 to 1 are interchangeable. The number of teeth are as follows for various ratios:

2¾ to 1; gear 36 teeth, pinion 13
3 to 1; gear 39 teeth, pinion 13.
3 7/11 to 1; gear 40 teeth, pinion 11.
4 to 1; gear 40 teeth, pinion 10.

Average speeds: 2¾ to 1; 60 to 65 m. p. h.: 3 to 1, 50 to 60 m. p. h.; 4 to 1, varies according to weight; average 25 to 35 m. p. h.

CHART NO. 828—Removing Rear Axle Assembly and Parts. Replacing Brake Shoes. Univers Joint. Gear Ratios.

See page 825 for Ford truck. *The Krom-nik Gear Co., 801 Grant Park Bldg., Chicago, supply differential ges 4.2 to 1 ratio for hilly country and 3 to 1 for racing purposes.

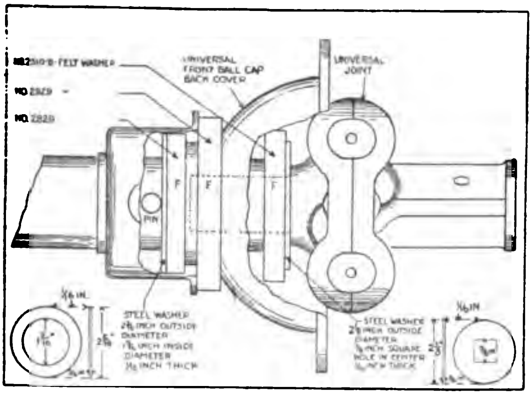

NO. 2510-B FELT WASHER
NO. 2829
NO. 2829
UNIVERSAL FRONT BALL CAP BACK COVER
UNIVERSAL JOINT
F
F
F
PIN
STEEL WASHER 2 1/16 INCH OUTSIDE DIAMETER 1 7/16 INCH INSIDE DIAMETER 1/16 INCH THICK
STEEL WASHER 2 1/8 INCH OUTSIDE DIAMETER 3/4 INCH SQUARE HOLE IN CENTER 1/16 INCH THICK
1/16 IN.
1/16 IN.

Fig. 31—Remedying excess of oil leakage out of wheel bearings: The oil from the transmission works down the drive shaft, through the universal joint through the differential out the axle ends, causing an excess of oil on the brakes.

To overcome this, place a felt washer at F. (Note the Ford stock numbers on these felt washers.) Then place steel washers (see illustration for size) as shown in illustration.

To put these washers in place, remove rear axle and rear half of universal joint, then remove front universal cover ball cap cover. Put felt and metal washer on as shown by placing same over transmission shaft. Then put No. 2829 washer on after cover is removed. Note the pin which will hold the washers in place. The washer 2510B and steel washer are easily applied when universal joint is apart. Reassemble carefully.

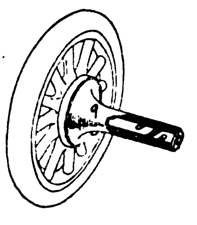


Fig. 32—shows another simple means of remedying this difficulty if too much lubricant is carried in the differential, for a time at least. Cut from a thick pad of felt a strip that is long enough to be wrapped around the axle shaft three or four times. This felt should be thick enough so as to fit snugly between the shaft and the housing and wrap it around the shaft as shown.

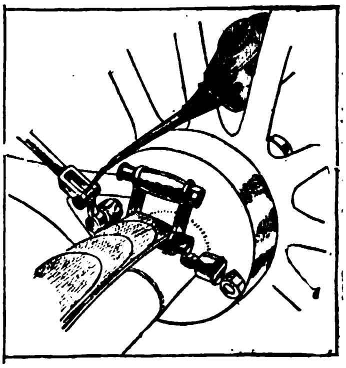


Fig. 34—When a Ford axle shaft becomes bent at the hub it may quickly be straightened by the device shown. An old Ford hub is attached to a heavy piece of pipe several feet long and this is slipped on the bent axle end while the engine is turned over slowly with high gear engaged. The end of the pipe will move in a circle due to the bend and by pulling pipe back to axle center the axle can be straightened.

Fig. 33—Oiling the emergency brake rod clevis pin.

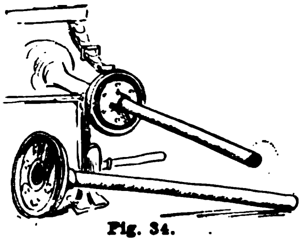


Fig. 34.

Grease Leaks from Rear Axle.

Grease leaks from rear axle: Due to too much grease. One and a half pounds of grease is plenty, but a small amount should be added every thousand miles.

Another reason for the leakage is, that in this construction Hyatt roller bearings are used, which tend to permit leakage of fluid or semi-fluid lubricants. The crown wheel (or main differential gear) takes up too great a quantity and distributes it to the shafts. The centrifugal action of these shafts carries the lubricant to the outer end and if felt washers are not in first class condition, the grease works out to the brake drums.

Worn thrust washers allow axle shafts and differential to shift from side to side and pump grease out. This usually causes the grease to appear around the left wheel first, as that wheel is nearer the drive gear.

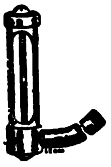
Worn thrust washers will cause the gears to grind. The noise will change as the car turns corners to right or left, and the weight of car is shifted from side to side.

Worn thrust washers require that the rear axle be removed from the car and taken apart, before new washers can be inserted. Ball bearing thrust washers are now made for Ford rear axles, and are claimed to wear longer. They should give less friction, and should therefore be useful for speedsters and racing.

The felt washers become worn and hard with use. They can be replaced—after removing the wheels—without taking the axle system off the car.

Two felt washers should be pushed on the axle shaft near the roller bearing next to the differential. A third felt washer should be placed near the outside end of the axle shaft, just inside of the outer roller bearing. These felt washers are cheap, and easily replaced, and, if only one pound of grease is used, will usually cure the rear axle grease leakage.

If light grease or oil is used it will leak out rapidly. If the grease is too stiff and heavy, the gears will simply cut a groove through the grease and the bearings will not be lubricated. Mobilubricant is often used for Ford rear axles, also Kaoga No. 2.



Oil gauge for Ford engine.

Fig. 35X: A glass gauge oil level indicator when screwed into the engine crank case will indicate the amount of oil at a glance. It is advisable to place a stop cock between gauge and crank case and keep it closed; only open when testing—to prevent loss of oil if gauge breaks.

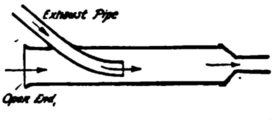


Fig. 35: To increase efficiency of exhaust for racing; a method, is to run pipes, with gradual bends from each exhaust port to an expansion chamber. Pipe leading from expansion chamber to rear should have a gradual increasing diameter to permit gases to expand as they cool.

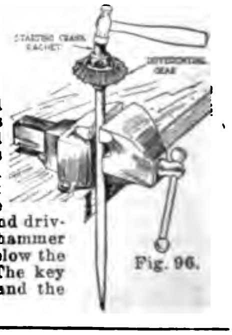


Fig. 96. — Ford differential gears can be removed from the shafts by placing an old starting-crank ratchet in the face of the gear and driving it with a hammer till the gear is below the half-moon key. The key is then removed and the gear driven off.

CHART NO. 329—Remedying Excess Oil Leakage out Rear Wheel Bearings. Axle Straightening.

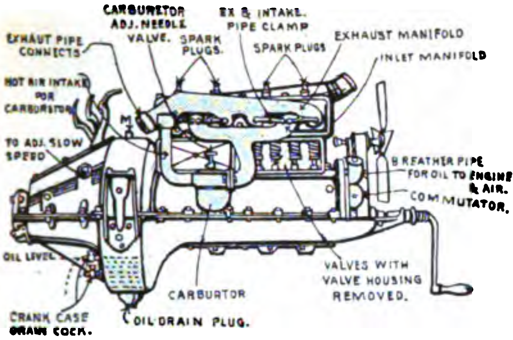


Fig. 36—Right side of Ford model T unit power plant. Showing inlet and exhaust manifold and valves.

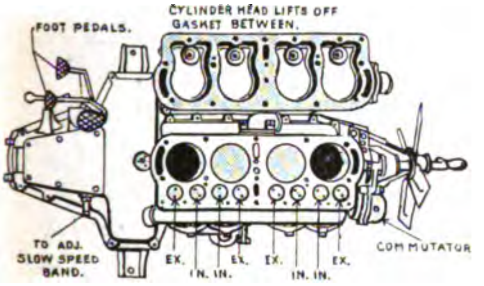


Fig. 38—Top view. Cylinder head removed showing cylinder bores, pistons and heads of valves in their seat. Note which are exhaust and which are inlet valves.

The Power Plant.

Engine, 4 cylinder, L head type with mechanically operated valves on the side. Bore 3¾ inches; stroke 4 inches. 22½ h. p. Cylinders are "en-bloc" type. Power plant is "unit type" because engine and transmission are combined so as to form practically one unit.

The cooling is by means of thermo syphon circulation as described on page 186 (figs. 1 and 2.)

Ignition; source of electric supply is an inductor type of magneto (described on pages 803, 805 and 265,) one part being attached to fly wheel and other part stationary. The current is carried to a commutator, thence to four high tension coils thence to spark plugs.

Carburetion; the Holley model G, and sometimes Kingston model Y carburetor is used as described on pages 798, 799 and 160.

Transmission; of the planetary type. It gives two speeds forward and one reverse. When driving on high speed the drive is direct and entire transmission revolves with drive shaft. When running on low speed the gears inside of low speed part of transmission are in action. The same when reversing.

The transmission is attached to the end of crank shaft (see charts No. 331, and 323,) and enclosed in a housing which covers transmission, fly wheel and magneto.

Gasoline feed system is gravity, see page 164.

Lubrication; gravity and splash. The fly wheel in revolving, picks up the oil and throws it by centrifugal force into the catch basin; from where it is led by ⅜ inch copper piping to the timing gears and then to the oil splash trough under the front cylinder. (see pages 772 and 197).

Location of Valves.

Location of valves: Front valve to the left of fan, (fig. 38), is No. 1 cylinder exhaust; then No. 1, inlet; then No. 2, inlet, No. 2, exhaust; No. 3 exhaust is next, then No. 3 inlet; No. 4 inlet and then No. 4 exhaust. Note the exhaust valves are next to the water jackets and nearest to the port openings where the cooling action is most effective.

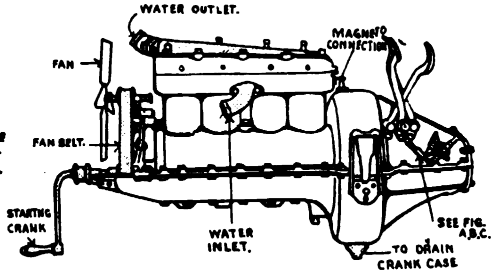


Fig. 37—Left side. Showing cooling water inlet and outlet. Note cylinders are "en-bloc," a typical unit power plant.

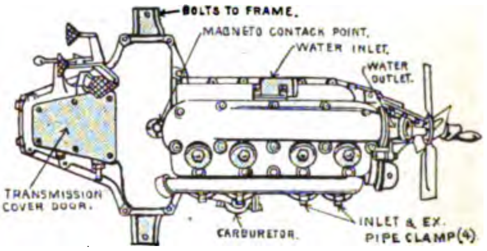


Fig. 39—The cylinder head is removed by taking off 15, $\frac{7}{16}$x2$\frac{9}{16}$ inch cap screws on top of cylinder. Underneath the head there is a gasket.

*Removing the Power Plant.

(1) Remove hood;

(2) Drain the radiator;

(3) Loosen bolts holding top hose connection; (see fig. 53, chart 335-A.)

(4) Loosen bolts holding side hose connection to cylinder block;

(5) Loosen radiator-to-dash stay rod;

(6) Remove nuts and washers from the two bolts holding the radiator to the chassis;

(7) Remove radiator; (see page 789);

(8) Loosen cap screw holding commutator. Place commutator and wires to one side;

(9) Remove spark plug, and magneto wires;

(10) Remove spark plugs;

(11) Remove cylinder head. (Makes engine lighter and easier to lift);

(12) Remove 4 bolts holding universal ball cover;

(13) Turn off gasoline and disconnect feed pipe from carburetor;

(14) Remove nuts from studs holding inlet and exhaust manifolds;

(15) Take off the inlet manifold, with carburetor attached;

(16) Take off exhaust manifold, with exhaust pipe complete;

(17) Remove the two bolts holding the pans to each side of the base and knock the pans down out of the way;

(18) Loosen nuts holding arm (A) fig. 9, page 773) on lower end of steering post;

(19) Remove three bolts holding steering column to chassis;

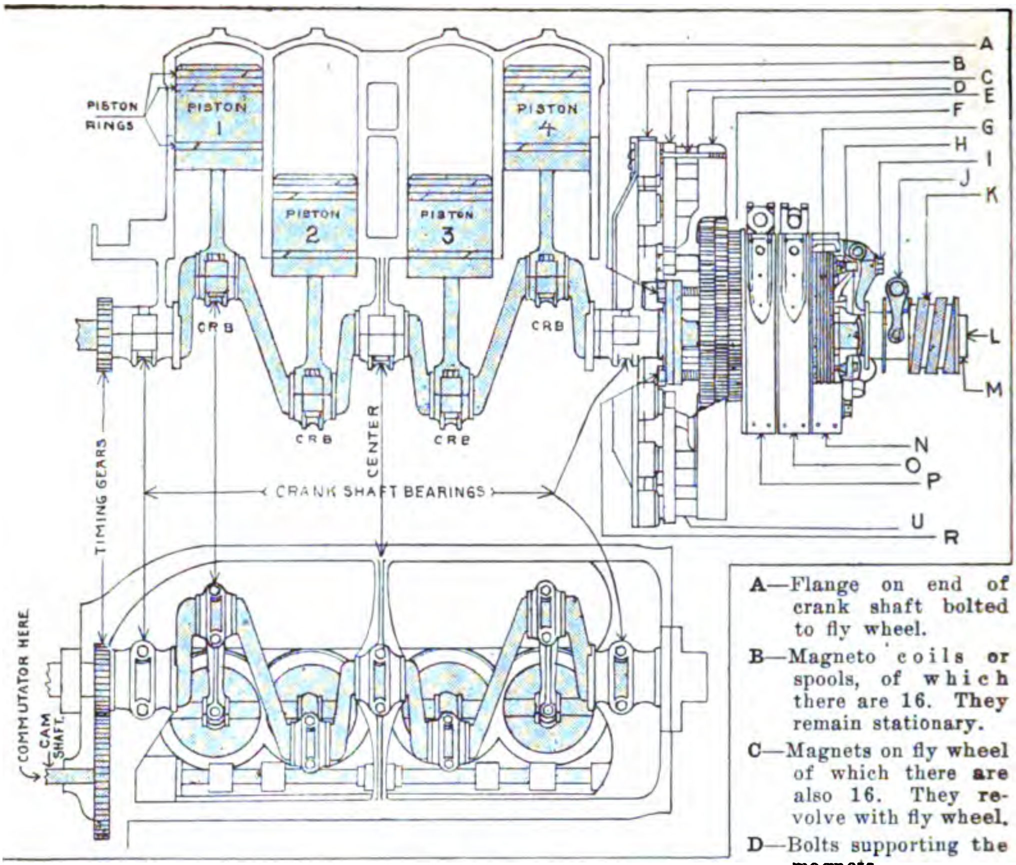
(20) Loosen dashboard, and pull dash and steering column up out of way. (Note: Not necessary to loosen dash or steering on 1917 cars);

(21) Remove nuts from front radius rod ball joint (see fig. 9-C, page 773);

(22) Loosen and remove bolts holding engine to frame, and then power plant can be lifted out.

CHART NO. 330—The Power Plant. Removing Power Plant. See also page 806.

See Insert No. 2, which is a half-tone engraving of the engine. *On 1917 and later cars, the engine can b **removed without removing the dash or steering gear.** The engine is brought forward until clear of dash, the lifted up to the right, to clear the steering gear.



When No. 1 is on	No. 2 is on	No. 4 is on	No. 3 is on
FIRING	Compression	Suction	Exhaust
Exhaust	FIRING	Compression	Suction
Suction	Exhaust	FIRING	Compression
Compression	Suction	Exhaust	FIRING

Engine—note, there are four pistons. The crank shaft is of the 180° type. When pistons No. 1 & 4 are up; No. 2 & 3 are down.

The Ford engine fires, 1, 2, 4, 3—that is, say No. 1 was starting down on firing stroke, No. 2 would be coming up on compression and would fire next; No. 4 would be going down on suction because it would fire after No. 2; No. 3 would be coming up on exhaust.

***Cam shaft speed**—Cam shaft runs ½ the speed of crank shaft, because the cam shaft gear is twice the size of the crank shaft gear. (see timing gear above and note small gear on end of crank shaft and larger cam gear on end of cam shaft.)

Cam shaft gear has 42 teeth and is 5⅓ inches in diameter. The crank shaft gear has 21 teeth and is 2⅔ inch in diameter.

A—Flange on end of crank shaft bolted to fly wheel.

B—Magneto coils or spools, of which there are 16. They remain stationary.

C—Magnets on fly wheel of which there are also 16. They revolve with fly wheel.

D—Bolts supporting the magnets.

E—Fly wheel, bolted to flange on crankshaft.

F—Planetary gears, called "sun and planet" type.

G—Clutch discs.

H—Ring which presses against clutch discs when fingers are pressed on by yoke J, which causes clutch adjusting screw (I) to press against ring (H) thereby pressing clutch disc plates (G) together, which causes drive shaft (L) to then transmit power through drive shaft to rear axle.

I—Adjusting screw for pressure of finger against ring and clutch. There are three of these and three fingers.

J—Yoke which throws clutch "in" and "out" by movement of side hand lever (see chart 325.)

K—Spring which forces collar against fingers.

L—Transmission shaft connecting with universal joint, thence drive shaft.

M—Collar supporting thrust of rear of spring.

N—Transmission brake band, applied by movement of foot lever, marked (B), (see chart 325).

O—Slow speed band applied by foot lever marked (C). The same lever operates clutch.

P—Reverse band applied by foot lever, marked (R), chart 325.

ART NO. 331—Sectional View of Engine. Plan View from Beneath. Firing Order. Valve Ar-
gement.

te: By mistake, only four cams are shown on cam shaft. There are eight as per fig. 9, page 86. See fig. 88, art 880 for location of valves. Also see Insert No. 2

Inlet valve opens 1/16 in. (piston travel) after top center on 1st stroke (as piston is 5/16 in. above cyl. when at top—it is now 1/4 in. above.)

Inlet valve closes 9/16 in. after bottom center on 2d stroke. (see last paragraph bottom of page).

Exhaust valve opens 5/16 in. before bottom center on 3d stroke. (see third paragraph from bottom of page).

Exhaust valve closes on top center of 4th stroke.

Note when piston is at top of stroke it is 5/16 in. above cyl. casting.

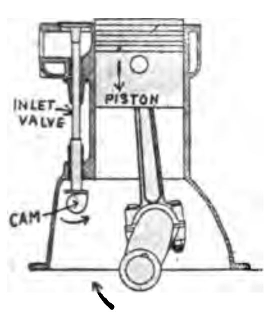


Fig. 41.

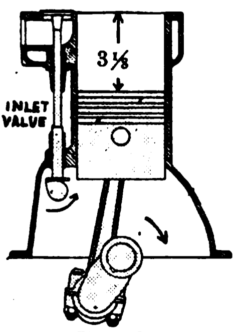


Fig. 42.

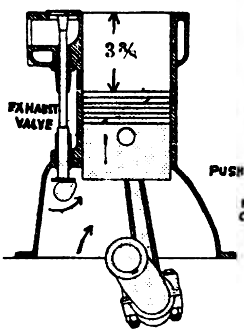


Fig. 43.

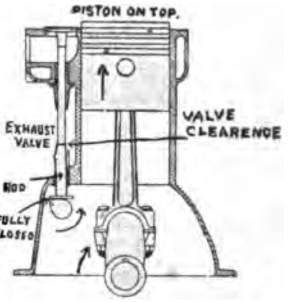
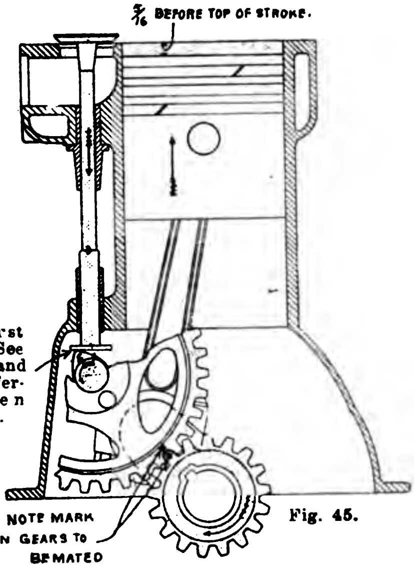


Fig. 44.



Ex-cam just leaving. See fig. 44 and note difference when fully closed.

Fig. 45.

Fig. 45—Position of exhaust cam for No. 1 cylinder when marked teeth on gears are engaged.

Note the exhaust valve is just on the point of closing but is not fully closed and piston is within 5/16 in. of top of its stroke.

*****Meshing the timing gears:** If the cam shaft is removed for any reason, care must be taken to replace it, so that the tooth of crank shaft gear, indicated by a mark (o) will mesh between the two teeth of the large time gear at the zero point.

In assembling the cam shaft to the large time gear, see that the first exhaust cam point is in the opposite direction from the zero mark on the gear.

*Valve Clearance.

When the valves or push rods become worn, so as to leave too much play between them, thus reducing the lift of the valves and diminishing the power of the engine, it is best to replace the push rods wth new ones.

The clearance between the push rod and the valve stem should never be greater than 1/32 in. nor less than 1/64 inch.

The correct clearance is naturally half way between these two measurements. The gap should be measured when the push rod is on the heel of the cam—per fig. 4, page 94.

If the clearance is greater, the valve will open late and close early, resulting in uneven running.

If the clearance is less than 1/64 in. there is danger of the valve remaining partially open all the time. (Don't get 'adjustment too close).

If replacing, if the push rod does not give the proper clearance, the valve should also be replaced.

If a new valve is fitted it will be necessary to grind it in (see page 680 for valve grinding.)

**Valve Timing.

Before timing or checking the valve timing, see that clearance is first adjusted.

Then check the timing; take cylinder No. 1. Remove cylinder head so that the position of pistons can be measured from the top. For instance; in checking the timing, the **exhaust valve starts** to open when the piston is 3 3/4 in. from the top of cylinder (not from top of stroke) 5/16 in. from bottom—say reach bottom and then move piston back 5/16 inch.

Timing the valves: Place piston 5/16" from top (level with top of cyl., as piston is 5/16" above it when on top of its stroke); turn cam shaft (gears out of mesh), until it is at point where exhaust valve is just closing (see fig. 45); the exhaust cam will then point away from the 0 mark on the cam shaft and crank shaft gears, which are directly opposite and on line.

Then mesh the cam and crank shaft gear as per paragraph three under fig. 45. No. 2 cylinder will then be on firing stroke. The roller will be either on or to one side of, the brass segment or contact point of the commutator, depending upon whether the spark is retarded or advanced. (see fig. 87 page 803 and fig. 2, page 316.)

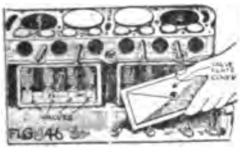


Fig. 46—Removal of valve cover in order to adjust clearance of tappets and valves.

Opening and Closing of Valves.

The exhaust valve opens when the piston reaches 5/16 in. before bottom center, the distance from top of the piston head to the top of the cylinder casting measuring 3 3/4 inches, (see fig. 43.)

The exhaust valve closes on top center, the piston being 5/16 in. above the cylinder casting (fig. 44).

The intake valve opens 1/16 inch after top center (fig. 41.) **Intake valve closes 9/16 in. after bottom center, the distance from the top of the piston to the top of the cylinder casting measuring 3 1/8 in. (fig. 42). In some instances, for speed work the gears can be meshed so that inlet will open a little sooner, but engine will not idle very well.**

CHART NO. 332—Valve Timing. Valve Clearance. Meshing Timing Gears.

*See page 95 for meaning of "Valve Clearance." **See page 316 for Ignition Timing. See page 57 for "Four Cycle" Principle. ***Spiral or helical timing gears are now used, instead of straight spur gears. Large time gear is No. 3047B and small one. No. 3048.

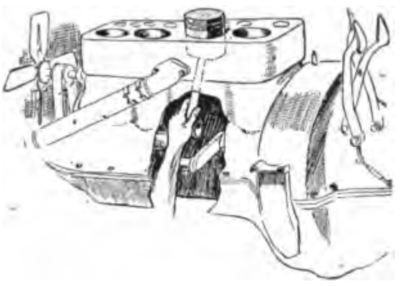


Fig 47—Removing conecting rod and piston: One method of getting at the piston is to take off the cylinder-head, remove the cover from the bottom of the crank case and, by reaching through this, remove the bolts holding the connecting-rod lower bearings in place. After the connecting-rod bearing caps are removed, the piston can be pushed up though the top of the cylinder.

The method of removing the piston is clearly illustrated. (Motor Age.)

To remove the piston pin; loosen connecting rod clamp screw.

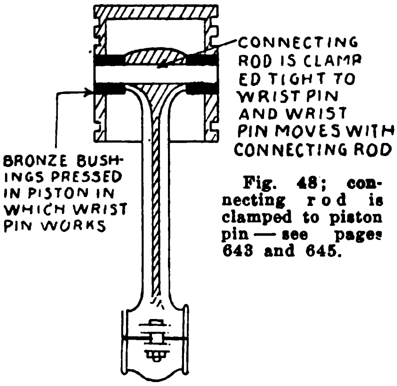

CONNECTING ROD IS CLAMPED TIGHT TO WRIST PIN AND WRIST PIN MOVES WITH CONNECTING ROD
BRONZE BUSHINGS PRESSED IN PISTON IN WHICH WRIST PIN WORKS

Fig. 48; connecting rod is clamped to piston pin — see pages 643 and 645.

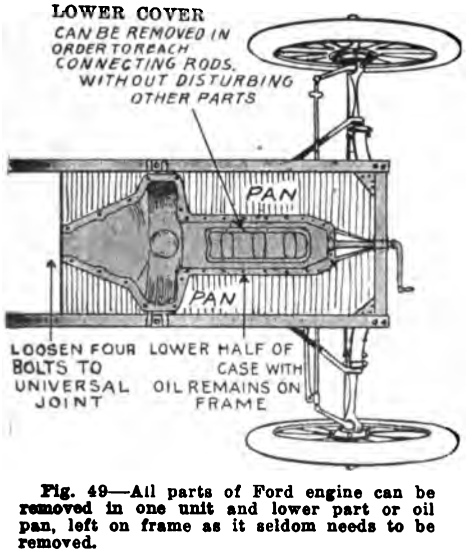

LOWER COVER
CAN BE REMOVED IN ORDER TO REACH CONNECTING RODS. WITHOUT DISTURBING OTHER PARTS
PAN
PAN
LOOSEN FOUR BOLTS TO UNIVERSAL JOINT
LOWER HALF OF CASE WITH OIL REMAINS ON FRAME

Fig. 49—All parts of Ford engine can be removed in one unit and lower part or oil pan, left on frame as it seldom needs to be removed.

To remove lower crank case cover, it is necessary to take out 14 capscrews ($\frac{5}{16}$x$\frac{7}{16}$ inch.) Be careful to not destroy gasket and watch for oil in pockets under connecting rods. Note the lower crank case cover is the part upper arrow points to.

*Connecting Rod Bearings.

Loose connecting rod bearings cause a rattle, or light knock, especially at light loads and high speeds. Heavier loads seem to steady the connecting rods.

Long wear, pounding due to carbon, a spark too far advanced, or forcing the engine to labor on high gear; as well as lack of, or poor quality of oil, are the chief causes of loose connecting rod bearings.

It is not necessary to drain the oil from the base, when making repairs to the connecting rod bearings, as the normal oil level is below the detachable plate on the bottom of the crankcase (see fig. 6, page 772.)

Adjusting Connecting Rod Bearings.

The connecting rod bearings may be adjusted, without taking out of the engine, as follows: (A) remove crank case lower cover plate on bottom of crank case and exposing the connecting rods; (B) remove the first connecting rod bearing cap, and draw-file the ends—just a little at a time; (C) replace the cap, being careful to see that punch marks correspond, and tighten bolts until it fits shaft snug; (D) test bearing for tightness by turning engine over by the starting handle; (E) now loosen the bearing and proceed to fit the other bearings in the same manner; (F) after each bearing has been properly fitted and tested, then tighten the cap bolts.

There is a possibility of getting the bearings too tight and under such conditions the babbitt is liable to cut out quickly, unless the engine is run slowly at the start. After adjusting the bearings, jack up the rear wheels and let the engine run slowly for about two hours (keeping it well supplied with water and oil) before going out on the road.

Removing No. 4 Connecting Rod Cap.

Bring the No. 4 connecting rod about halfway up on the up stroke. Remove the cotter pin and nut, from the right connecting rod bolt. Now turn crankshaft over, by means of the starting crank, until the connecting rod cap is about halfway down on the other side. Pull out the other cotter pin and remove the nut from the bolt. Ford socket wrench No. 2322 can be used, if a couple of inches is cut off from the handle. Or, Walden wrench No. 5810 is specially made to reach this nut, and is very useful for this purpose (see chart 341.)

Be careful that the nuts and parts do not fall into the transmission case, and mark the connecting rod cap with a center punch before taking it off. so that it can be replaced in exactly the same position.

Removing Piston and Connecting Rods.

See fig. 47 above.

When connecting rods become worn, they may be returned, prepaid, to the nearest Ford agent or branch house for exchange at a price of 75 cents each to cover the cost of rebabbitting. It is not advisable for any owner or repair shop to attempt the rebabbitting of connecting rods or main bearings, for without a special jig in which to form the bearings, satisfactory results will not be obtained. The constant tapping of a loose connecting rod on the crank shaft will eventually produce crystallization of the steel—result, broken crank shaft and possibly other parts of the engine damaged.

HART NO. 333—Connecting Rod and Bearings. Removing Pistons and Connecting Rods. Three oint Suspension of Power Plant.

See also page 641, 642, 643.

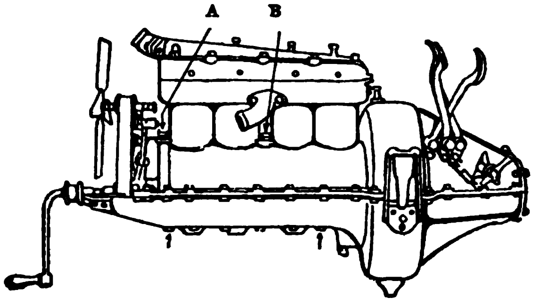


Fig. 50—To remove the center and front main bearing—remove nuts at (A) and (B) and draw long crank shaft bearing bolts (½"x6$\frac{1}{16}$"x20 threads) out from bottom, when lower bearing caps can be removed. It is not necessary to remove engine from frame.

To remove rear main bearing it is necessary to remove the engine from frame. If a special Ford wrench No. 1929 is used, one fly wheel bolt, holding fly wheel to end of crank shaft (see page 784) can be removed without further dismantling and then remove the two bearing nuts off lower part and bearing cap will lift off.

To remove the cylinder head: Disconnect water hose from top plate,* after first draining radiator, disconnect spark plug wires. Remove cap screws holding head to cylinders and lift off. This can be done without removing engine from frame. (see also page 783).

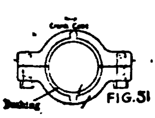


FIG.51

Fig. 51—Illustration showing the main bearing cap and bearing bushing, which is babbitt lined. Shims between bearing cap and upper bearing not shown.

The three main bearings on crankshaft are babbitted. On the old 1910 models, the upper halves of the main bearings were plain iron and not babbitted.

Crank Shaft Main Bearings.

Wear of the main bearings of the crankshaft will be evident by a rather heavy pound or thud, especially when the engine is pulling hard under a heavy load. (see page 639.)

Wear of these main bearings may be due to; long use; not enough, or poor quality oil; allowing the engine to knock; from carrying the spark too far advanced, or carbon in the cylinders; to a sprung crankshaft; or failure to drain out the old oil regularly.

The rear main bearing carries the heaviest load and is usually the first to show signs of wear. This rear bearing supports the flywheel, the magneto, and one end of the transmission, in addition to supporting the crankshaft against the thrust of the pistons.

Looseness in the rear main bearing, may be detected by running the engine on No. 4 cylinder and having the throttle wide open—this will show up a loose main bearing.

The rear main bearing cannot be tightened, without taking the engine out of the car as explained under fig. 50. The middle bearing can be tightened, without taking the engine out of the car, but seldom needs adjusting unless the other bearings need it also.

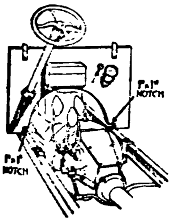


Fig. 51A—To remove the Ford engine from the frame without raising body from frame; take a hacksaw and cut out a square 1 in. by 1 in. on each side of the dash. (Motor World.)

**Adjusting Bearings.

First: Take engine out of the car, remove crank case, transmission cover, cylinder head, pistons, connecting rods, transmission and magneto coils. Remove the three babbitted caps and clean the bearing surfaces with gasoline. Prussian blue is then applied, or red lead, to the bearing surfaces of the crank shaft, which will enable one to determine whether a perfect bearing surface is obtained when fitting the caps.

Second; put the rear cap in position first, and tighten it up as much as possible being careful to not strip the bolt threads. Bearing, when properly fitted will permit the crank shaft moving with one hand.

If it cannot be turned with one hand, between the bearing surface, contact is too close, and the cap requires shimming up, one or two thin shims usually being sufficient.

If the crank shaft moves too easily with one hand, the shims should be removed and the steel surface of the cap filed off, thereby causing it to set closer.

Third; after the cap has been removed, note whether the blue or red "spottings" indicate a full bearing the length of the cap. If "spottings" do not show a true bearing surface, the babbitt should be scraped and the cap refitted until it fits properly.

Fourth; the rear cap can now be laid aside and the adjustment of the center bearing can be made in the same manner. The operation can be repeated with the front bearing.

Fifth; after you have obtained the proper adjustment of each bearing, the babbitt surface should be cleaned carefully and a little lubricating oil placed on the bearings, and the crank shaft; then draw the caps up as close as possible—making sure the necessary shims are in place. There is no danger of getting the cap bolts too tight, as the shim under the cap and the oil between the bearing surfaces will prevent the metal being drawn into too close. Put oil on the bearing surfaces, otherwise the babbitt is apt to cut out when the engine is started before the oil in the crank case can get into the bearing. When the crank case and transmission cover on the engine is replaced, a new set of felt gaskets to prevent oil leaks, should be fitted.

CHART NO. 334—Crank Shaft Main Bearings. Adjusting Bearings.

---

*See fig. 58, page 789. See foot note, page 814 relative to counterbalances for Ford crank shafts.

**See also pages 641, 642, 643.

To Remove Crank Shaft.

First remove connecting rods and the main bearings, disconnect the bolts holding the flywheel to the flange of the crankshaft, using Ford special wrench No. 1929.

Removing the Camshaft.

It is sometimes necessary to remove the camshaft in order to install new push rods, or to replace worn camshaft bearings, as the bearings are sometimes the source of knocks that are difficult to locate.

It is a comparatively easy matter to remove the camshaft when the engine is out of the car, but, contrary to the opinion of many owners of Ford cars, it is also fairly easy to remove the camshaft without removing the engine.

Procedure for camshaft removal: Remove the pin which holds the fan belt pulley on the crankshaft. (see fig. 78A, page 796.) Drive the fan belt pulley forward. Remove the cap screws, which hold the cylinder front cover to the cylinder block. Remove the commutator brush assembly, after driving out the pin which holds it to the cam shaft. Now the cylinder front cover can be removed. Next, remove the two cap screws in the side of the cylinder block which hold the camshaft bearings in place.

It may now be possible to pull out the camshaft with its bearings, but if not, the plate on the lower part of the crank case should be removed, after the cap screws which hold this plate to the crank case have been taken out.

Then a drift, or brass bar, can be used to drive the camshaft out from below, holding the end of the brass bar against one of the cams and striking the other end of the bar with a hammer. Care should be taken not to punch a hole through the cast iron cylinder block while doing this part of the work.

After the camshaft has been removed, the push rods will drop down and can be removed through the opening in the bottom of the crank case. Be sure to remove all the push rods.

Installing New Push Rods.

Place the new push rods in the guides. Small holes, near the top of each push rod, will now be noticed. After putting the push rods in place, slip nails, or a piece of wire, through these holes, to keep them in position while the camshaft is being replaced. Then the camshaft and its bearings can be driven in, and the cap screws (which hold the bearings) tightened.

The marks on the small crank shaft gear and on the large timing gear should be placed together, and the valves tested to make certain that the valves open and close at the proper time. Then the front cylinder cover plate should be replaced, and the timer brush assembly and also the timer cover. Then the fan belt pulley and the starting crank pin, and finally the fan belt. (Fordowner.)

Causes and Cures of Overheating.*

Carbon, in the cylinders.
Remove the cylinder head and scrape out the carbon, as directed on pages 790 and 624.

Driving on low gear.
The engine should not be raced, when driving on low gear, and the spark should be well advanced, because the engine speed is comparatively high. Do not use low, when high speed can be used without straining the engine.

Spark retarded too far.
Keep the spark advanced as far as possible, without causing the engine to knock. As the throttle is opened and the engine slows down, it is necessary to retard the spark.

Poor ignition.
If the engine is misfiring it is necessary to open the throttle much wider and retard the spark; this tends to cause overheating.

Insufficient or poor quality of oil.
Lack of oil will cause such friction between the pistons and the cylinder walls that the engine will overheat and the pistons may stick. Poor oil burns up, or becomes thin and runs away so quickly that the parts are left practically without oil. Use good oil—it costs less in the long run.

Racing the engine.
Close the throttle when the clutch is disengaged, and so save gasoline and prevent overheating.

Clogged muffler; too rich a mixture or too much oil will deposit soot in the muffler and by preventing the escape of the exhaust, will cause overheating. Clean the muffler by disassembling it. (see page 84.)

Water frozen—steams (see page 579-193).
To thaw out—open drain cock—water usually freezes at bottom of radiator—therefore pour hot water on bottom until circulation starts. This will be indicated by water running out of drain cock. Then close drain cock and fill radiator with water and keep engine running. Sometimes when engine steams if a blanket is thrown over the engine and radiator the heat will thaw out bottom of radiator.—see pages 579-193-800.

Fan not working properly.
A broken, or a loose and slipping belt will not rotate the fan fast enough to draw a cooling current of air through the radiator. This will especially tend to cause overheating when the engine is idling or running on low gear. Tighten or replace the belt. Perhaps it may be necessary to bend the fan blades at a slightly sharper angle, in order to draw more air through the radiator. (see fig. 52.)

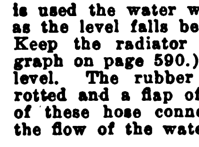


Fig. 52.

Poor water circulation.
Due to low water. As the thermo-syphon system is used the water will cease to circulate as soon as the level falls below the inlet to the radiator. Keep the radiator well filled. (see last paragraph on page 590.) Leaks may lower the water level. The rubber hose connections may have rotted and a flap of rubber on the inside of one of these hose connections may seriously impede the flow of the water.

Don't get alarmed if the water boils occasionally, especially in driving through mud and deep sand or up long hills in extremely warm weather. Remember that the engine develops the greatest efficiency when the water is heated nearly to the boiling point. But if there is persistent overheating when the engine is working under ordinary conditions—find the cause of the trouble and remedy it. The chances are that the difficulty lies in improper driving or carbonized cylinders.

No trouble can result rfom the filling of a heated radiator with cold water—providing the water system is not entirely empty—in which case the engine should be allowed to cool before the cold water is introduced.

CHART NO. 335—Removing Crank and Cam Shafts. Causes and Cures of Overheating.

---

*See pages 189 and 579.

Cleaning Radiator.

The circulating system should be carefully washed out, early in the spring, because the anti-freezing solutions, used in the winter, are apt to leave the tube clogged up. In summer, it is advisable to flush out the circulating system about once a month (see page 191).

To do this properly, the radiator inlet and outlet hose should be disconnected, and the radiator flushed out by allowing the water to enter the filler neck at ordinary pressure, from whence it will flow down through the tubes and out at the drain cock and hose.

The water jackets can be flushed out in the same manner. Simply allow the water to enter into the cylinder head connection and to flow through the water jackets and out at the side inlet connection.

Repairing leaky radiators, is hardly ever easy, although temporary repairs can often be made by the use of iron cement or cold solder (see page 715), or by wrapping the damaged tubes with tire tape. But the leak should be soldered at the first convenient opportunity.

A jammed radiator tube is a more serious affair. While the stopping of one tube does not seriously interfere with the circulation, it is bound to cause trouble sooner or later—and the tube will freeze in cold weather. Cut the tube an inch above and below the jam and insert a new piece, soldering the connections. If the entire radiator is badly jammed or broken it would probably be advisable to install a new one.

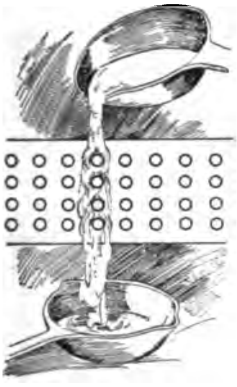


Fig. 1—Illustrating how solder is poured over the leaky radiator tubes

New radiator tubes can be purchased separately, for about five cents each, but it is necessary to take the radiator almost entirely apart before a new tube can be inserted.

A new core or nest of radiator tubes and fins can also be purchased. If the radiator is badly damaged, by freezing or collision, it is often advisable to have a new core installed by a skilled radiator repairman.

If the radiator-to-dash stay rod rattles, tighten the rod nut.

Painting the radiator. Do not use a bright aluminum, gold paint, or heavy enamel on the radiator fins or tubes, as these retard the radiation of the heat and are apt to cause the engine to overheat.—(see pages 194, 509, 591 and 786).

It is no simple matter to pry the fins of the Ford radiator back to get at and solder up the leaky tubes, and the resulting job is usually bad looking, if not properly done. Herein is outlined a simple method of repair that does not destroy its appearance.

Testing.

After the removal of the radiator from the car, the first thing to do is to test it. The inlet, outlet and filler cap must be plugged, so that air pressure may be applied to the drain tube. Then if the radiator be put under water, the bubbles will show where the leaks are.

Fig. 2 shows the plug used to stop up the intake. Another just like it is used to plug the return. It comprises three rubber packing discs, and a soft rubber disc all mounted on a bolt, and capable of being compressed by a steel block and a cam. The discs are cut to fit in the intake, or return, as the case may be. The plug is shoved in as far as it will go, and cam tightened. This squeezes the discs, forcing them out, and closing up the opening.

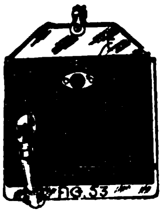


Fig. 53—When removing, leave hose and flange on.

Fig. 3—The filler opening seal is shown attached. A rubber pad is held by a metal plate over the opening, the whole being screw braced against a stirrup caught over threaded head of filler snout.

The air pressure is applied to the radiator through the overflow pipe, and then it is immersed in a tank full of water, and the leaks determined by the bubbles. The leaky parts are then marked.

Repairing.

The radiator is placed on a bench and the leaky part of the tubes heated with a blow torch. When quite hot—a little hotter than boiling—muriatic acid soldering solution is poured through the fins, all over the leaky tubes, to clean their surfaces

***Fig. 1—A ladleful of solder is melted.** The radiator is bolstered up from the bench on blocks, and the melted solder poured through the radiator, over the leaky tubes. Note the method of catching the excess solder.

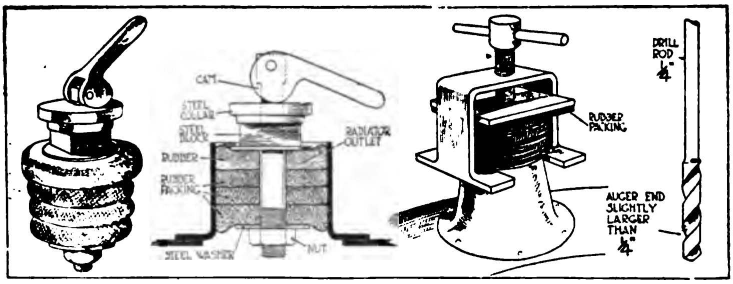


Fig. 2—Left—Rubber plug used to stop passages to radiator. Fig. 3—Center—Clamp for closing radiator filler cap. Fig. 4—Right—Drill rod for expanding tube ends

Then the radiator is turned over and the solder poured in from other side in exactly same manner.

A little more acid is then added and a torch applied to melt the solder and sweat it into all the leaks, closing them permanently.

Though leaks and splits of quite a large size may be fixed this way, it is occasionally necessary to tear the radiator down and put in new tubes. The hardest part of the job is tearing the radiator down to the core and building it up again, as this requires a good man with the soldering iron.

After removing the two headers from the core, each tube is tested for leaks, and if leaky, marked.

Providing no greater number than 10 tubes are defective, the radiator may be repaired. Any greater number than 10 makes a new core advisable.

Fig. 4—Each of the defective tubes is expanded by the tool. It is a piece of ¼-in. drill rod, upset at the end, and ground down into a sort of drill. This is run through the leaky tubes.

Then a new radiator tube is shoved through each of these expanded tubes, and the ends sweated to the outside of the old tubes. The radiator is then ready for assembling.

The main precautions to observe in putting the radiator together are to have the surfaces clean, have the iron well tinned, clean and hot, and to use plenty of soldering compound. A little experience should enable any mechanic to do this job well, and at a profit to himself. (Motor World.)

CHART NO. 335-A—Repairing the Radiator. See also pages 194, 714 and 715.

*What is known commercially as "50-50 solder" is adapted for this class of work—see also, pages 711, 715

*Compression and Grinding the Valves.

If the compression is poor, and the pistons and rings fit well, the valve may need grinding or adjusting. The compression can be tested, when the engine is warm, by pulling up slowly on the starting crank. The compression should be springy and elastic, but not as lively as that of other cars, on account of the drag and friction in the Ford transmission. (see pages 627 to 629.)

Removing Valves for Grinding.

Drain radiator. Remove cylinder head, and the valve covers on the right side of the engine. Use valve lifting tool (fig. 61, page 633 also see chart 343) to compress valve springs and pull the pins out of the ends of the valve stems. Then valves can be pulled out.

Grinding the Valves.

A good grinding paste can be made of ground glass and oil—obtainable from auto supply houses. One method, is to put a small amount in a can top and add a spoonful or two of kerosene and a few drops of lubricating oil to make a thin paste.

Place the mixture on the bevel face of the valve sparingly. Place a spring under valve as shown on page 631. Put the valve in position on the valve seat, and rotate it back and forth (about a quarter turn) a few times, with a grinding tool. (see page 616.) Then lift slightly from the seat, change the position and continue the rotation and keep on repeating this operation until the bearing surface is smooth and bright. The valve should not be turned through a complete rotation, as this is apt to cause scratches running around the entire circumference of the valve and seat.

When the grinding is completed remove the valve from the cylinder, thoroughly washed with kerosene, and wipe out the valve seat thoroughly. Care should be taken that none of the abrasive gets into the cylinders or valve guides. This can be avoided if the grinding paste is applied sparingly to the bevel face of the valve. (see pages 630 to 633.)

When the valve seat is worn badly or seamed, it is then advisable to have it reseated with a valve seating tool. Care should be exercised against making too deep a cut, otherwise the retiming of the valve will be necessary. (see chart 337.)

Valve Springs.

If the valves fail to seat properly, it may be due to weak or broken springs. Weak inlet springs would probably not affect the running of the engine, but weak exhaust valve springs cause uneven action, which is difficult to locate.

It will cause a lag in the engine due to the exhaust valve not closing instantly, and the result will be, a certain percentage of the charge under compression escapes, greatly reducing the force of the explosion.

A weak valve spring can usually be detected by the following method: Remove the valve plate (fig. 46, page 785) and insert a screw driver between the coils of the spring while the engine is running. If the extra tension thus produced causes the engine to pick up speed, the spring is weak and a new one should be replaced.

Valve springs consist of 11¼ coils of No. 104 music wire, complete spring is 2⅞ inches long and $^{31}/_{32}$ inch outside diameter.

**Causes of Engine Knocks.

(1) **Carbon,** is the most frequent cause of engine knocks.

(2) **The spark too far advanced,** will waste power and cause a knock.

(3) **Loose connecting rod bearings,** will cause knocks.

(4) **Worn crank shaft main bearings cause knocks.**

(5) **Piston slap,** due to loose piston.

(6) **Worn or broken piston rings,** will cause a light knock.

(7) **Piston striking the cylinder head gasket.**

(8) **Loose camshaft bearings.**

(9) **Valve tappets out of adjustment,** or badly worn, will cause noise.

How to Distinguish Knocks.

(1) The carbon knock is a clear, hollow sound, most noticeable in climbing sharp grades, particularly when the engine is heated. It is also indicated by a sharp rap immediately on advancing the throttle.

(2) Too advanced spark will be indicated by a dull knock in the engine.

(3) The connecting rod knock sounds like the distant tapping of steel with a small hammer, and is readily distinguished when the car is allowed to run idly down grade—or upon speeding the car to twenty five miles an hour, then suddenly closing the throttle the tapping will be very distinct.

(4) The crank shaft main bearing knock can be distinguished, when the car is going uphill, as a dull thud.

(5) The loose piston knock is heard only upon suddenly opening the throttle, when the sound produced might be likened to a rattle. (see also pages 635 and 637 to 639.)

Before and After Carbon Cleaning.

First, drain the water off by opening the pet cock at the bottom of the radiator; then disconnect the wires at the top of the engine and also the radiator connection attached to the radiator. Remove the 15 cap screws which holds the cylinder head in place. Take off the cylinder head and, with a putty knife or screw driver, scrape from the cylinder and piston heads the carbonized matter (as per fig. 54) being careful to prevent the specks of carbon from getting into the cylinders or other openings.

In replacing the cylinder head gasket turn the engine over so that No. 1 and No. 4 pistons are at top center; place the gasket in position over the pistons and then put the cylinder head in place. Be sure and draw the cylinder head capscrews down evenly (i. e., give each one a few turns at a time); do not tighten them at one end before drawing them up at the other.

Removing Carbon.

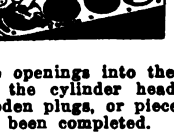


FIG. 54

Fig. 54—Carbon removal is most easily done with a putty knife, after the cylinder head has been removed. The flexible putty knife follows the surface better than the stiff and narrow blade of a screwdriver. Do not get the carbon in the openings into the water jacket. This would tend to impede the flow of the water and might cause overheating of the engine. The openings into the water jackets and the holes for the cylinder head bolts can be plugged with wooden plugs, or pieces of cloth, until the scraping has been completed. (see page 624.)

r NO. 336—Grinding Valves. Valve Springs. Causes of Knocks. Carbon Removal.

ages 798 and 817. **See also pages 685 to 689.

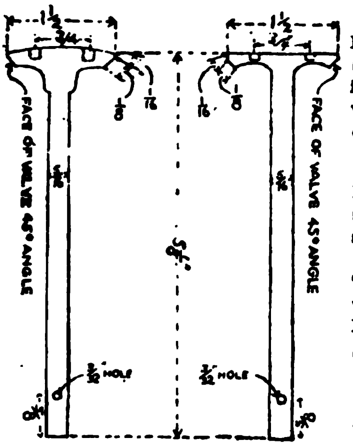


Fig. 55. Fig. 56.

Fig. 55 — Dimensions of finished Cast iron head valve (standard.)

Fig. 56 — Dimensions of finished Tungsten valve Made by Rich Tool Co., Railway Exchange Bldg., Chicago, Ill.

(Shape of valve is more like one shown in fig. 61).

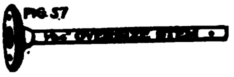


FIG. 57

Fig: 57 — Oversize valve stems are necessary when worn valve guides are reamed out. The standard oversize valve stem is 1/64 inch, (or in other words the valve guide is reamed that much) larger. If the standard valve stem was 5/16 inch, then it would be 1/64 inch larger or 21/64 inch diameter.

Worn valve guides not only cause noise, but admit air to the mixture which causes misfiring and bad starting.

Ford valve guides are a part of the cylinder casting and cannot be renewed. Reaming and fitting oversize valves is a better method than to ream the guide large enough to put in a bushing. Unless a great deal of metal was removed, the bushing would be so thin that it would not last long.

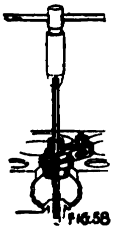


FIG 58

Fig. 58—A valve guide reamer: When reaming the valve guides it is necessary to ream true, therefore a guide is necessary, the guide is shown clamped to cylinder head. The reamer is then passed through the guide and turned by a hand tap wrench. This outfit sells for $1.50.

Fig. 60—Valve seat reamer: is used for the same purpose in the valve seat as the refacer is used on the valve face. Just enough reaming is necessary to remove the pitting.*

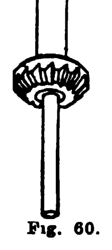


Fig. 60.

Can Ford valves be enlarged? This question is often asked. There is hardly enough metal to permit reaming out the valve ports more than 5/16 inch. The diameter of the standard Ford valve is 1¼ inches (measured at the seat.) Reaming out valve seats to make them larger, is attended with grave risks of cutting through the metal and ruining the cylinder block, especially if the cores were not set exactly true when the casting was made.

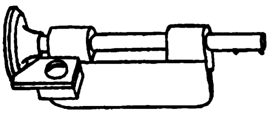

VALVE RE-FACER

Fig. 59—Valve refacer: When Ford valves are badly pitted it is nearly impossible to get a perfect seat and the tool shown is designed to overcome this difficulty by refacing the valve instead of grinding (see also page 632).

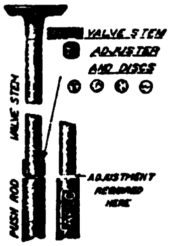


Fig. 61—Valve clearance adjusters: When the space between the end of the push rod (fig. 44, chart 382) and the end of the valve stem is more than 1/32 inch (see page 785 this instruction) then a clicking noise is the result. As the Ford valve has no means of adjustment it is remedied by either installing new valves and **push rods or using adjusters as shown in this illustration.

Valve adjusters can be secured at the supply houses to place on end of valves if too far apart. They are made of hardened steel. The cap fits over end of valve and any number discs can be put in until space is as desired. They are made in 5/16, ⅜ and 7/16 inch sizes. Fibre washers can also be obtained for the same purpose, which reduces the noise considerably.

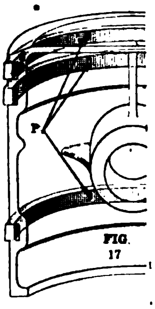


FIG. 17

Ford piston rings: are cut with a slight taper so that the ring will bear on the lower edge. This is done so the ring will scrape the surplus oil from the cylinder wall on the down stroke, thus preventing an excess of oil getting to the compression chamber.

There is a punch mark on the inside, upper edge of the Ford rings (see P, fig. 17). On the earlier rings, there was a file mark in upper edge, to show which side to place up. If ring is upside down, it will have a tendency to pump oil. See also, pages 792 and 793.

Overhead Valves for Ford Engine

with 16 valves is made by Laurel Motors Corporation, Anderson, Ind., and give the engine increased speed and power for racing so it is claimed. **They are made complete with a special cylinder head and manifolds. As they are equipped with sixteen valves,—instead of the usual eight,—the gases can be admitted and expelled from the cylinders with less wasted time, and so the engine gains both power and speed. But overhead valves are generally considered more noisy, than valves enclosed at the side. The necessity for keeping sixteen valves ground and adjusted would seem to confine this type to racers and speedsters rather than for general use. The heating of engine is overcome by using a larger size radiator and a circulating pump.**

The Craig-Hunt Co., Indianapolis, also manufacture a 16 valve, overhead cam shaft complete for the Ford.

CHART NO. 387—Valve Dimensions. Valve Adjusters. Valve Guide Reamer. Valve Refacer an Reseater.

---

*There is a limit to the amount of reaming that can be done. If reamed too often, eventually the valves wi be lowered enough to form a pocket. (see fig. 8, page 712.) **Push-rods 1/64-in. oversize can be secured c **supply houses.**

Pistons—Cast Iron.

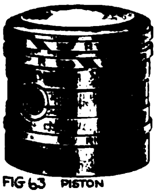


FIG 63 PISTON

Fig. 63—The standard Ford piston is 3¾ inches diameter. The piston pin* is the oscillating type as explained on page 645. Therefore **bushings are necessary in the bosses for the piston pin to oscillate in. The pistons come with the bushings fitted. †Oversizes which can be secured are 3¾ inch plus .0025, .005. .015 and .030. (G. H. Dyer Co., Cambridge, Mass.)

Rings—There are three rings, two placed above and one below, as shown in fig. 63. They measure 3¾ inches diameter by ¼ inch width (about .004 less). Rings to fit oversize pistons can also be secured. (see pages 653 to 659, for ring fitting, etc., also page 609.)

The rings are eccentric and thinner at the ends. Thickness at center is about .150 inch, at ends .085 inch. See also, page 791, 649.

Aluminum Ford Pistons.

FIG64

Fig. 64—Aluminum pistons also called "Lynite," are being advocated by various manufacturers. They claim that by reducing the weight of the reciprocating parts it lessens the vibration and permits quicker "pick-up" and higher engine speeds.

Aluminum expands more rapidly than cast iron. Hence, these pistons must be fitted with greater clearance to keep them from sticking in the cylinders when the engine becomes very hot.

Clearance* varies according to design and type of piston and speed of engine.

For average speeds; .007 to .008 at skirt, and .014 to .016 at top.

For racing; 60 to 70 m. p. h., .014 to .015 at skirt and .024 to .027 at top.

As aluminum conducts the heat away more rapidly, it is claimed that less carbon forms on the top of an aluminum piston. It is also claimed that there is less friction between piston and cylinder walls, and that they cause less wear on the cast iron cylinder walls.

Most aluminum pistons are supplied with some form of special piston rings, which are intended to prevent the leakage of the gases, thus increasing both the power and the economy. The extra clearance, when cold, is supposed to make the engine easier to crank, but unless carefully fitted, aluminum pistons are apt to slap (see page 637) and rattle at low engine speeds, until they become warmed up and expand to a more perfect fit.

The McQuay-Norris Co. of St. Louis, Mo., manufacturers of the "Lynite" Ford piston, state that the pistons they supply can be furnished in standard 3¾ inches diameter and 1⁄32 inch larger or to be exact 31 thousandths oversize. Also by special order any intermediate size (in thousandths of an inch) between the two dimensions just given. In ordering odd sizes, the exact diameter of cyl. bore must be given in order that the proper clearance can be allowed for pistons.

When ordering pistons always state if "standard" or "oversize" is wanted and if latter, caliper cylinder walls carefully, per page 649.

The Butler Mfg. Co. of Indianapolis, supply aluminum pistons in sizes .002 to 1⁄16 inch and special orders 3⁄32 inch larger than the standard size of 3¾ inches. They also state that from .0020 to .0025 clearance is allowed. They further state that 3⁄32 inch is the limit for reboring to oversize, (see pages 651 and 645 for piston clearance etc.)

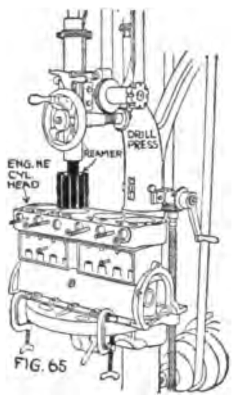


FIG. 65

Fig. 65 — Shows a reamer which can be fitted to an ordinary drill press geared down to 30 rev. per minute. It is fitted with a No. 4 Morse Taper shank. Cylinders can be enlarged to 1⁄32 inch oversize, so that 1⁄32 inch Ford standard oversize pistons and rings can be fitted.

‡Enlarging Ford Cylinders.

When oversize pistons are fitted to cylinders it is usual to rebore, ream or grind the cylinders out to the proper size. There are different methods for doing this as explained on pages 653, 654 and 616. In some instances, after an engine has been driven for 10 to 20 thousand miles, the walls may wear slightly and a slight oversize piston may be fitted without enlarging cylinder.†

Aligning Reamer.

Fig. 66—Is a reamer designed to ream all three main bearings simultaneously and saves much time in scraping and refitting bearings.

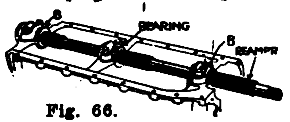


Fig. 66.

The unequal distribution of weight and driving strain on the crank shaft of a Ford engine naturally causes unequal wear in the main bearing. It can be seen that tightening up only on the bearing caps will spring the shaft out of line and throw additional strain on the bearings, causing them to wear loose again very rapidly. This reamer will bring all bearings to proper size and perfect alignment. An allowance of .0025 inch is made for wear of crank shaft.

This reamer can also be used for reaming the connecting rod lower bearings, as they are the same diameter as the main bearings.

††Special Reamers For Ford.

Fig. 67—Expanding reamer: A good set of reamers are very essential to the repairman. This particular reamer marketed by Stevens Co., 375 Broadway, N. Y. is an expanding type. They are ground .005 inch undersize and can be brought up to .005 inch oversize. This is an added advantage.

FIG.67 Expanding Reamer

PLAIN Reamer

Reamers are used for reaming out such parts as piston pin bushings, steering spring bushings, transmission triple gear bushings, cam shaft front and rear bushings etc. In fact they are indespensible to the repairman.

Reamer for spindle body and spindle arm bushing: A 2-in-1 reamer for front axle bushings. The 5-inch section reams the spindle body bushings in perfect alignment at one operation.

The 1-inch section is for use in the spindle arm bushing, price each $2.40.

Reamer for piston pin bushing: Used for reaming through both the piston pin bushings for perfect alignment of piston pins, price each $1.75.

Straight Flute

Spiral Flute

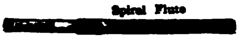


Fig. 68—Reamers are usually made with either straight or spiral flutes. (see page 706). Stevens Co., 375 Broadway, N. Y. supply reamers.

HART NO. 338—Pistons; standard and oversize. Cast Iron and Aluminum. Reamers for Cylinlers, Main-Bearing, Spindles, etc.

---

*Piston pin is 47⁄64 inch dia. x 3½ inches long. ‡See advertisement of South Bend Lathe Works.

**Piston pin bushings (pairs) are phosphor bronze, 15⁄16 inch dia. x 1 7⁄32 inches long.

†Standard oversize piston is 3¾ plus 1⁄32 inch, which is used when cylinder is rebored. .0025 can be used in worn cylinders without reboring—but by carefully lapping. If cylinder is out of round then reboring is necessary. ††Reamers for transmission bushings, piston bushings and main bearings can be secured of K. R. Wilson, 10-16 Lock St., Buffalo, N. Y.

Over-Lubrication of Cylinders.

*When the spark plug is constantly oily or fouled and constantly missing and excess of smoke is emitted out of the exhaust, this indicates that too much oil is working past the piston rings, or at least too much oil is passing into combustion chamber from crank case.

Causes.

(1) The oil level in crank case may be carried too high. It should not be above the upper petcock in the crankcase. (see fig. 6, chart 820).

(2) The front spring may be sagged. If the front end of the engine is lower than the rear, the oil will not drain back into the sump until there is too much oil under the front piston. A heavier pad between the front spring and the frame will level the engine.

(3) The cylinder bore may be worn oval by the side thrust of the connecting rods on the pistons, or the cylinder walls may be grooved and scored. All four cylinders should be rebored at the same time, and fitted with oversize pistons.

(4) The points of the spark plugs may be too close together, thus allowing oil to short-circuit them too easily. Bend the points slightly farther apart and (not over 1/32 inch) bend the side electrode upward, so that the oil will drain off to one side and not collect between the points.

(5) Leaky piston rings—page 653 and 655.

A broken piston ring will be indicated by a click or light knock, by loss of compression, and by smoke from the oil filler pipe or crankcase breather.

Well fitted pistons and rings will almost invariably cure trouble caused by overlubrication of the cylinder. If it does not, and none of the above is the cause, then the engine is afflicted with what is termed "piston pumping oil" which is explained on page 653 and the remedy is to doctor the rings and piston.

‡Remedying Piston Pumping Oil.

One method is to install a patented leak proof type ring (see page 655.) The patented ring is usually placed at the top, to hold the compression above the piston, but is sometimes placed at the bottom as it is claimed that less oil will be used in this way. The use of all three patented rings, (if a tight fit) will sometimes prevent the walls of cylinders getting a sufficient amount of oil—therefore this must be considered and probably lapping the ring to cylinder as explained on page 657 will help.

Another method, fig. 69—shows a piston doctored to prevent oil leaks; a patent two-piece ring, which is designed to hold the compression. Below the second ring (about four) 5/16 in. holes are drilled through the piston concave walls which allow oil scraped from the cylinder walls by the rings to run through these holes back to crank case.

The bottom ring has one edge beveled or chamfered as shown in fig. 69. The chamfered edge of the ring should be placed upward, as shown on the piston, so that the chamfered edge will slip over the oil, while the sharp edge on the bottom of the ring will scrape off the excess oil and force it back into the crankcase on the downward stroke. (see also page 658, "piston pumping oil.")

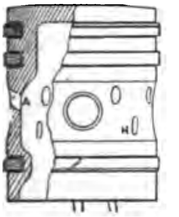


Fig. 69.

Fig. 70 shows a method of chamfering the lower part of the 3 rings and is usually all that is necessary. This should be tried before fitting a patent ring or drilling piston.

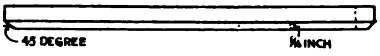


Fig. 70.

To chamfer means to bevel the part (as shown in illustration) with a file or emery wheel. Note illustration gives an idea as to the amount and angle of the chamfer. This will permit cylinders to get oil but will prevent oil working past rings into combustion chamber, providing of course, cylinder walls are not "scored" (cut) see pages 652, 650 and 658.

‡‡Piston Clearance.

Ford pistons should be fitted with a clearance between pistons and cylinder walls of from .002 to .005 inch. Less than .002 inch is apt to cause sticking and more than .005 is apt to cause "piston slap" (see page 637).

Further instructions on the fitting of pistons and rings can be found by referring to pages 650 and 657.

**Increasing Compression.

This means that by reducing the space in the combustion chamber from head of piston to inside top of compression chamber of cylinder—when piston is in its uppermost position—the gas would be compressed tighter, therefore more explosive force when combustion takes place.

Opinions vary on this. For high speed work it might possibly help—but the heating will increase and a circulating pump or larger radiator (special racing type—see page 820) will probably be required. Refer to page 627, under head of "Compression"—also page 817.

The question was recently asked of a manufacturer of Ford parts as follows:

(Q.) Would you advise cutting cylinder base down ⅛ inch to increase compression on engine for racing?

(A.) "It is much easier to plane off the cylinder head. Another method would be to use **special pistons to increase compression ⅛ inch.** We had an experimental machine fitted in this manner and found satisfactory, and is no doubt the most practical way. Increased water capacity is necessary and some form of circulating device such as a pump advisable."

Right here the writer wishes to add that in a recent race tournament of Fords, not one of the engines had increased compression. (see page 817.)

"Running In" Engine.

After engine has been overhauled, new rings, bearings, etc. fitted, it is a good plan to jack up rear wheels per fig. 72, put about 1¼ gallons of lubricating oil in crank case, put water hose in radiator and run engine for several hours to work rings and bearings "in." Note when "running in" an engine, the water should be kept running constantly.

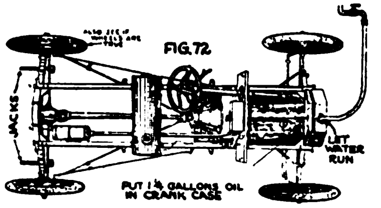


FIG.72.

When doing this work, the engine is usually out of the frame of car, therefore another plan would be to place the engine on a stand made for the purpose as in fig. 73 and run engine from a belt from line shaft. This of course is for a repair shop with considerable work. See also page 828.

Many, after fitting parts and first following plan shown in fig. 72, then take car out and run **slow and carefully—not over 12 to 15 m. p. h. for the first 500 miles**—this is very important as cylinders are liable to be cut. Use plenty of good oil.

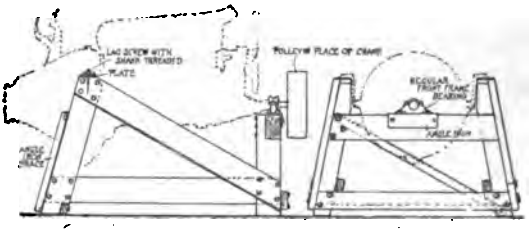


Fig. 73—Engine stand constructed of wood. A regular front bearing bracket of the Ford is attached to stand to form the support for the front end. (See adv. Continental Auto Parts Co.)

CHART NO. 339—Over Lubrication of Cylinders. "Running In" Engine. Increasing Compressio

*See page 586. "Spark Plugs Indicate Valve Condition." **See also pages 640, 629, 817 and 909.

*The treatment applies only to those cylinders in which the spark plugs are constantly oil soaked, usual No. 1 (front), and often No. 4 (rear). ‡See also, pages 652, 791. ‡‡See page 649; how to measure p

*Fair Charges for Overhauling a Ford.

The prices given on this list are for individual repairs, and are the labor charges only. The materials used and the parts installed should be charged for extra, according to the established prices given in the Ford parts price list.

The prices charged are amply high to cover the best quality of work, the work can be guaranteed at these prices, and the repair shop will make a fair profit on the work.

Engine Division.

	Charge for Labor.
Overhaul—	
Engine and transmission	$18.00
Engine only (or engine and transmission out of car)	14.50
Transmission	11.00
Repair	
Burned out bearing	10.50
Main bearing knock	8.50
Put in two or more pistons	6.00
Cylinder knock	5.00
Put in two or more connecting rods or repair oil leak	5.00
Put in one new piston	5.00
Leak in crank case	5.00
Put in one connecting rod	8.75
Grind valves, clean carbon	2.75
Change transmission bands	2.50
Rebore and rebabbitt cylinder block including fitting of pistons	8.00
Rebore cylinder block only	2.00
Tighten transmission gasket cover on case, or rebush transmission	2.50
Cylinder head bolts (stripped)	2.50
Replace crank shaft starting pin	1.50
Cylinder front cover	2.00
Overhaul carburetor	2.00
Braze crank case arm only	1.50
Change cylinder head gasket	1.25
Tighten engine to frame	1.25
Commutator wire loom and brush	1.00
Assemble fly wheel only	1.00
Change carburetor	.75
Leaky door or clean crank case	.60
Change fan pulley assembly	.60
Commutator pull rod ball joint	.50
Leaky carburetor	1.00

Rear System Division.

Overhaul rear axle or install new housing	$ 6.00
Change rear radius rod	1.50
Replace—	
Rear spring, tie bolt, or new leaf, including graphiting leaves and line up body rear spring tie bolt only	8.00
Rear spring tie bolt only	1.50
Rear axle assembly	8.00
Rebush system	3.00
Repair—	
Install universal joint	2.50
Shaft straighten	1.50
Dope leak, one side	1.00
Install brake shoes, each	1.00
Equalize emergency brakes and fit brake shoes or repair hand brake lever quadrant	1.25
Emergency brake only	.75
Tighten universal joint	.60
Change truss rods, each	.60
Change brake rod supports each	.60
Install or tighten rear spring retainer clip	.60

Front System Division.

Rebush front axle	$ 5.00
Rebush spindles (each side, $1.50)	3.00
Repair—	
Broken off radius rod ball cap stud	2.50
Straighten front axle	2.50
Front spring tie bolt—or new leaf, including polishing and graphiting leaves	2.00
Front spring or tie bolt—replace only	1.00
Tighten ball cap or replace radius rod	.60

Chassis Division.

Replace steering gear	$ 3.00
Replace fenders, each	.50
Replace front cross member	6.00
Repair—	
Overhaul radiator	6.00
Remove shock absorbers—oil graphite spring	5.00
Leaky radiator—off the car	3.75
Straighten front cross member	3.00
Overhaul steering gear	3.00
Change coil with Yale lock	3.00
Replace muffler	.50
Install running board bracket	2.50
Starting crank	1.25
Install engine pans	1.25
Tighten steering gear	1.25
Replace wheel (1) $ .60; (4)	1.25
Leaky radiator—on the car	1.00
Wheel, overhaul or change hub—each (cones and ball race)	1.00
Adjust clutch	.60
Starting crank ratchet pin	.60
Gasoline feed pipe or generator tube	.60
Tighten muffler or engine pan	.60
Install radiator or replace hose connection, each	.60
Tighten or replace fender or running board	.60
Dope car	.50

Body Division.

Repair—repaint and varnish car	$20.00
Refit curtains and recover top	10.00
Reupholster body (if new material used)	10.00
Change closed bodies	8.00
Change touring car or runabout body	5.00
Tighten all bolts	5.00
Change dash	5.00
Change bow on top, each	2.50
Install (1) windshield glass	1.25
Install (2) windshield glass	2.00
Refinishing deck on torpedo body	1.50
Tighten all doors	1.25
Tighten dash to body, or replace horn	1.25
Replace top iron, each	1.00
Holes in top	1.00
Replace windshield, tighten hinge screws or dash clips	.50
Replace celluloid lights, each	.60
Dent out of rear panel and refinish	10.00
Dent out of rear panel	8.00
Any side panel and refinish	6.00
Any side panel	4.00
Take dent out of door and refinish	8.00
Take dent out of door	2.00
Overhaul Model "T" touring car or runabout, including: Repainting car Repairing body, cushions and upholstering Top repaired or recovered Motor and transmission overhauled Rear system overhauled Front system overhauled	55.00

Of course, if the car is equipped with an electric starting and lighting device, or even with a mechanical starter, this may make the work of overhauling more difficult, and so the repair shop will be quite justified in making an extra charge for the extra labor involved. If the car is fitted with shock absorbers or other supplementary springs, this may make it more difficult to remove the rear axle and an extra charge is justifiable.

What Constitutes an Overhaul.

The customary labor charge for a complete overhaul of a Ford touring car or runabout is $55.00. This is for labor only, the cost of the parts installed being charged for extra and usually making the total charge about $75.00, for a complete overhauling. If the body of the car is not painted, an allowance of $5.00 for labor is usually deducted from this charge. The cost of the paint and varnish is included in the labor charge. **A complete overhauling should include:**

Removal of carbon from the engine, see chart 336 and pages 623 to 626.

Grinding the valves, if necessary, and adjusting valve tappet clearance, see charts 336 and 332, and pages 630 to 635.

Cleaning gasoline line, and the carburetor, see pages 162, 160.

Flushing radiator and water jackets of engine; see pages 191, chart 335.

Cleaning out old oil from crankcase, see page 201.

Cleaning differential housing and filling with grease, see page 772.

Clutch adjustment and relining transmission bands, see pages 776 and 777.

Adjustment of connecting rod and main bearings, see pages 786, 787, 641 and 646.

Fitting of pistons and rings, see pages 650, 657 to 659.

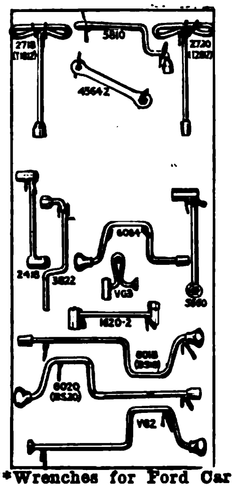
Adjusting, or replacing rear hub brake shoes, see page 781.

Tighten steering gear, and spring clips and small parts, see page 778.

HART NO. 340—Fair Prices for Overhauling Ford Cars.

downer Magazine.)

also page 595.



****Wrenches for Ford Car.**

Axle housing bolt and nut	6064-1620
Ball socket bolt and nut	2718
Brake band	4564
Brake & rev. sup. bolt & nut	6020-2720
Brake shoe support nut	2418
Brake shoe support bolt	6020-2720
Clutch lever screw and nut	2418-6018
Clutch release fork clamp screw	2718
Commutator case support bolt	6018-2718
Connecting rod clamp screw	2418
Connecting rod cap bolt and nut	5810
Crank case arm bolt and nut	2718
Crank case lower cover screw	6064-1620
Crank shaft bearing nut cen. & front	2418
Crank shaft rear bearing nut	2418
Cylinder cover & crank case	2418-6018
Cylinder cover bolt and nut	6018-2718
Cylinder cover cap screw	6018-2718
Cylinder inlet connecting screw	1620
Cylinder head cap screw	1620
Cylinder head outlet con. screw	1620
Cylinder valve cover stud and nut	2718
Differential case stud & nut	1620
Differential drive gear screw	6064-1620
Drive shaft pinion castle nut	5660
D. S. Roller bearing stud and nut	1620
Fan adjusting screw and nut	6018-2718
Fan bracket bolt	2418
Fly wheel cap screw	3822
Front fender iron bolt & nut	6064-1620
Front radius rod ball cap scr.	6018-2718
Front radius rod nut	2418
Front spring clip nut	5660
Front spring tie bolt and nut	1620
Hub bolt and nut	5660
Inlet & exh'st clamp stud & nut	6018-2718
Magnet bolt	6018-2718
Main bearing nut	2418
Main bearing bolt head	1620
Muffler bracket bolt & nut	6018-2718
Muffler rod nut	6064-1620
Oil lamp bracket screw and nut	2418
Radiator stud and nut	6018-2718
Radius rod bolt and nut	5660
Rear fender iron bolt and nut	6064-1620
Rear spring tie bolt and nut	1620
Rear hub lock nut	5660
Rear spring clip nut	5660
Reverse band	4564
Run board fender bolt and nut	1620
Running board bolt and nut	1620
Slow speed connecting lock nut	4564
Spindle arm nut	5660
Spindle bolt nut	2418
Spindle bolt	2418
Spindle con. rod bolt	2418
Steering gear post castle nut	6024-2418
Steering post bracket	2418-6018
Transmission band adjusting screw	4564
Trans. band adj. screw nut	6018-2718
Transmission band adjusting nut	4564
Trans. cover bolt & nut	6018-2718
Universal ball cap screw	2718
Valve grinding tools, VG2, VG3.	

****"St. Louis" Evenlite.**

This device (fig. 10), controls the current from magneto and produces full candlepower of lights at 10 miles per hour and will afford a full, clear light at 6 or 7 miles with a very slight decrease from highest speed. Price complete, to go in dash under hood $4.00. To go on steering post, including a horn push button and switch on the device, so lights can be turned on, dimmed or cut off, price $6.00 Can be connected in 30 minutes.

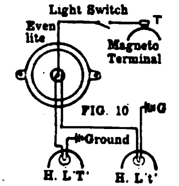
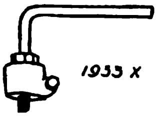
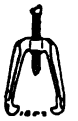
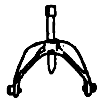


FIG. 10


1933 X

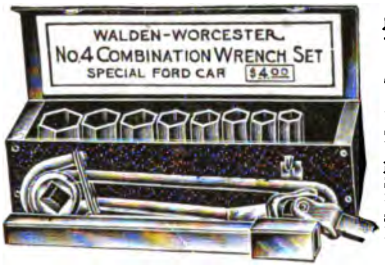

1936X


1953X

Ford Special Tools. Rear wheel puller assembly: old No. 1933X, new No. 3Z-612; **cam gear puller;** old No. 1936X, new No. 3Z-611; **transmission clutch puller;** old No. 1953X, new No. 3Z-614.

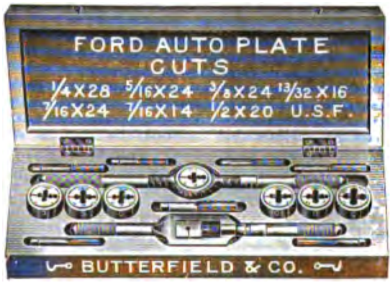
Cotter Pins for Ford Cars. There are a total of 95 cotter pins used throughout the car, and 6 different sizes, as enumerated to the right.

5—3/32 x 1/2"	No. 56.
33—3/32 x 5/8"	No. 88.
27—3/32 x 3/4"	No. 753.
4—3/32 x 1"	No. 421.
11—1/16 x 1/2"	No. 544.
15— 1/8 x 1"	No. 82.



No. 4 — Combination wrench set: arranged for the Ford car but good for all cars.**

Contains No. 511 ratchet wrench, 9"; extension bar, 9"; Universal joint; 8 pressed steel sockets. Sizes 17/32, 19/32, 21/32, 23/32, 25/32, 29/32, 31/32, and 1 5/32". Price $4.00.



****Butterfield screw plate is designed for Ford Work, contains taps and dies, cutting all the threads for bolts and screws on the Ford. Made by Butterfield Co., at Derby Line, Vt.** (Also see page 613).

Inspection After Repairing;
See to the Following:

1—Cylinder head tight.
2—All spark plugs firing, and tight.
3—Fan belt tight.
4—Fan bracket bolt and cotter pins tight.
5—Adjust carburetor properly.
6—Water connections tight and no leaks.
7—Hood properly fit.
8—Head lamps burn, properly focused, connections tight.
9—Front wheels adjusted, lubricated and lined up.
10—Fenders and running board bolts and nuts tight.
11—Doors work properly.
12—Emergency brake adjusted.
13—Trans. bands adjusted.
14—Floor boards fit properly.
15—Grease in rear axle.
16—Grease in all cups.
17—Oil in engine.
18—Water in radiator.
19—Tires properly inflated.
20—Examine tool kit.
21—Curtains fit.
22—Horn in working condition.

CHART NO. 341—Wrenches (Socket). Taps and Dies. Wheel and Gear Pullers. What Numbe Wrench to Use.

---

*See also page 613, and page 704, for taps and dies, "how to use."
**Can be secured of A. L. Dyke, Electric Dept., Granite Bldg., St. Louis, Mo.

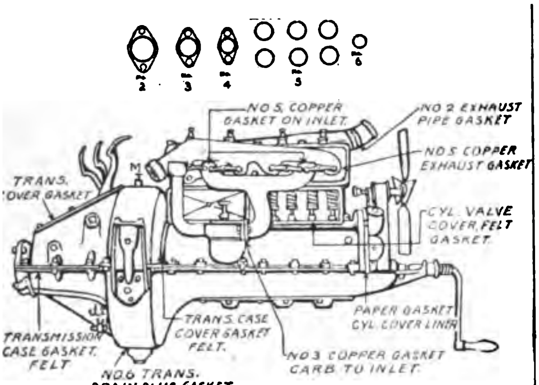

2
3
4
5
6
NO 5 COPPER GASKET ON INLET.
NO 2 EXHAUST PIPE GASKET
NO 5 COPPER EXHAUST GASKET
TRANS. COVER GASKET
M
CYL. VALVE COVER, FELT GASKET.
PAPER GASKET CYL. COVER LINER
TRANS. CASE COVER GASKET FELT.
TRANSMISSION CASE GASKET. FELT
NO 3 COPPER GASKET CARB. TO INLET.
NO.6 TRANS. DRAIN PLUG GASKET.

Fig. 74—Right side of Ford engine showing different location and kinds of gaskets used.

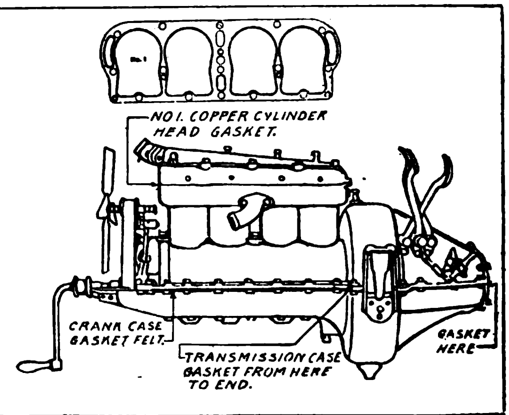

NO 1. COPPER CYLINDER HEAD GASKET.
CRANK CASE GASKET FELT.
TRANSMISSION CASE GASKET FROM HERE TO END.
GASKET HERE

Fig. 75—Left side of Ford engine showing location and kinds of gaskets used.

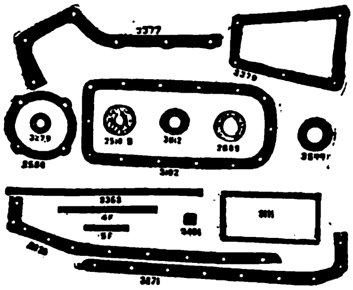


Fig. ,u

Gaskets.

Set of gaskets and felt washers for Ford car. 2580—Universal ball cap gasket. 3070—Crank case and cyl. gasket, L. H. 3071—Crank case and cyl. gasket, R. H. 3102—Crank case lower cover gasket. 3111—Cyl. valve cover gasket. 3363—Trans. cover front gasket. 3377—Trans. cover gasket. 3379—Trans. sloping door gasket. 3451—Control bracket felt. 4-F—Trans. cover strip 7¾x⅛x3/64 inch. 5-F—Crank case arm strip 3⅛x⅛x3/64 inch. 3544—Steering bracket. 2510B—For rear axle, 2 7/16x⅞x5/16 in. 2809—For front hub, 2⅛ in. diam. 3012—For cyl. cover, 2x 1 5/16x ⅜ in. 3279—For mag. contact, 1⅛x¾x3/64 inch.

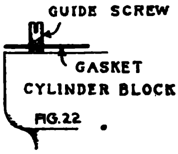


Fig. 78—Guide screws are handy for correct replacement of cylinder head gasket. They are made from cap screws with head cut off and slotted. Place one at front and rear diagonally opposite. Then place gasket over guide screws and replace cylinder head. Screws can then be removed.

Cylinder Head Gaskets.

There is a copper-asbestos gasket between the cylinder head and the cylinder block. There is practically no water pressure on this gasket, but there is a cylinder pressure, of from sixty pounds on the compression stroke to 250 pounds on the firing stroke, which must be withstood by the gasket. As the cylinder head bolts contract, when cool, and expand when hot,—there are varying degrees of pressure on the gasket, so the cylinder head must be securely seated to keep the cylinder head gasket from blowing out.

The gasket is composed of asbestos fabric, between sheets of brass and copper. (see page 717.) If examined closely, one end of the gasket will be found to have a different curve than the other. When the gasket is placed on the cylinder block, with its edges coinciding with the edges of the block,—the right side of the gasket will be turned upward, and no further trouble will be experienced.

Shellac, should not be used, on either side of the cylinder head gasket or on any of the other gaskets on the engine. If shellac is used, it will not be possible to remove the gasket without spoiling it. But, if grease is used, the grease will hold the gasket in place when the parts are being assembled, and it will cause no trouble when the engine is again taken apart. In this manner cylinder head gasket can be used several times.

The metal surfaces, between which any of the gaskets are clamped, should be clean and free from grit. A small lump of dirt will tend to cause a leak and spoil the gasket.

Asbestos can be substituted for head of cylinder if copper cannot be secured—sheet asbestos, size 1/16 thick x 7 x 20 inches.

Cylinder Head Cap Screws.

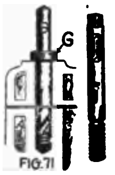
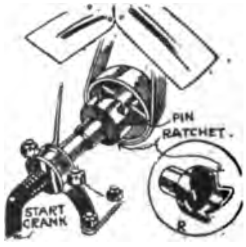


FIG.71

Cap screws are sometimes broken off when being tightened. Ordinarily, this involves the removal of the cylinder head and the attempt to drill out the broken part of the bolt. It is not easy to hold the drill perfectly true, so that the threads will not be damaged but by the use of the drill guide (G) furnished with the set, the drill can be held perfectly central, without the necessity of removing the cylinder head. Then the threads can be cleaned out with the 7/16 inch tap, and the new bolt installed. The cylinder bolts must be kept rather tight, or water is apt to escape around the cylinder head gasket. (see also page 709.

If cylinder head cap screw threads becomes stripped, it is not advisable to drill a hole in head for an "oversize" screw, but drill cylinder block, tap and set in not less than a ⅝x18 thread blind plug, then drill and tap for standard cap screw (7/16x14.) 7/16 means the size of screw and 14 means the number of threads to the inch.



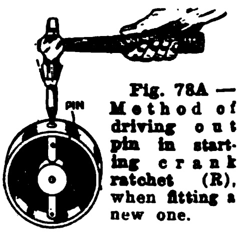
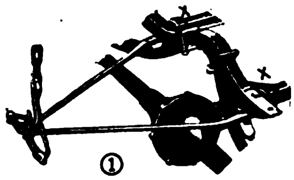


Fig. 78A — Method of driving out pin in starting crank ratchet (R), when fitting a new one.

CHART NO. 342—Gaskets. Broken Cylinder Head Capscrews. Stripped Threads. Starting Crank Repair.

Device for Raising Rear End of Car.

Fig. 1 shows the hook in position for raising the rear end of car. By means of this device the rear end of the car can be held up securely while removing or repairing the rear axle assembly or spring. In attaching the hook place the clamps on end of each bar on the frame, then bring the ends of the bars together, one bar resting in the safety clevis on the other bar. The links are then placed in the hook on the chain block and the car easily raised.



①

Fig 1-A shows in detail with specifications the method of constructing the rear end hook. This equipment can be made by local blacksmiths and Ford agents will find it an efficient help in their repair work.

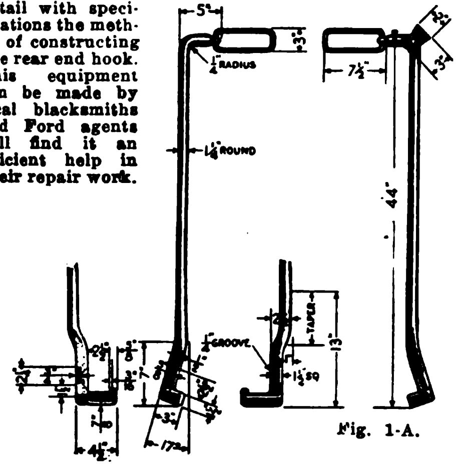
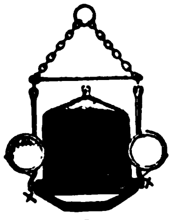


Fig. 1-A.

Device for Raising Front End of Car.

Fig. 2 shows device in position for raising the front end of a Ford car while removing or repairing front axle or spring. Each hook is placed on the fender iron below the nut on end of the lamp bracket. The ring is placed in the hook on the chain-block and the car easily raised.

Ford agents will be able to have this equipment made by local blacksmiths from the details and specifications shown in fig. 2-A. The front end hook should be part of the equipment of every Ford repair shop. (Ford Times.)



②

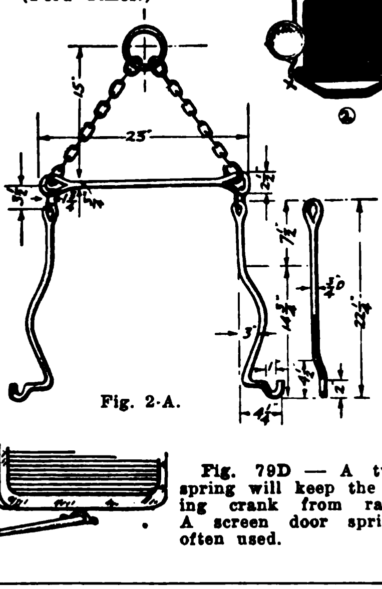


Fig. 2-A.

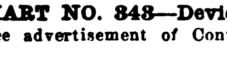


Fig. 79D — A twisted spring will keep the starting crank from rattling. A screen door spring is often used.

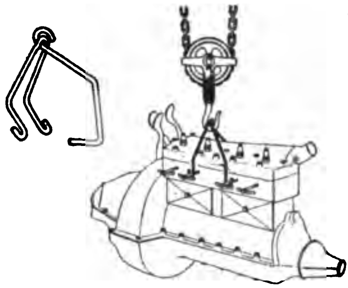


Fig. 79A—Engine lifting hook; used in conjunction with a chain block to remove the engine from the frame. It is in two parts, one U-shaped, and bent in the manner shown, having eyes to catch two manifold stud nuts, the other fastened to it, and bent to grab below the water jacket between the second and third cylinders. Ordinarily the manifolds, cylinder head, transmission case cover and crank-case base are removed, the illustration showing the application of the hook. When these are removed the engine will balance.

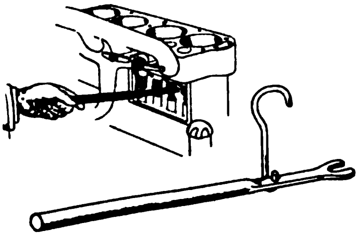
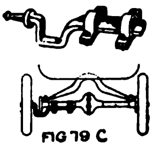


Fig. 79B—Tool for removing the valves may be made from a piece of steel ⅝ in. round and about 12 or 14 in. long. One end is flattened out for about 4 in. and then drilled ¼ in., and the flattened end is then notched in the manner shown to permit insertion beneath the valve locking washer. A piece of ¼ in. rod is then bent at both ends, one end passing through the ¼-inch hole in the lever and the other being used to hook over one of the manifold studs. By the aid of this lifter the valve may be removed without removing either manifold.

Towing in a Ford when the differential happens to lock or rear axle becomes defective—loosen hub caps, remove wheels and withdraw the keys in axle shafts. The wheels are replaced and car can be towed in with wheels turning free. Note—grease well before starting.

Auxiliary Wheel for Disabled Fords.



Ford cars disabled by having the rear axle broken near the hub may be towed in by the aid of the device shown. A bar of steel about 8 ft. long and 1½ in. square is put in the lathe and a standard Ford hub turned on one end and fitted with the cones and locking nut. The other end of the bar is then forged out flat and bent to clear the rear brake band, after which the lower clamping straps are riveted on. The addition of the upper clamping straps and a standard Ford wheel makes the outfit complete. To use, the disabled car is jacked up and the auxiliary wheel clamped in place, permitting the car to be towed in. In the case of a front wheel the procedure is much the same, except that the cross-steering rod must be tied and the car towed very slowly. The device is not limited to use on the Ford, and has been used to bring in a 1-ton truck.

*Rear Axle Stand.

Fig. 79: Constructed of channel iron throughout, each upright laid out at a point of an L on the floor as shown. One-half of the rear axle housing passes through, and is held by two of these uprights, the other upright holding the torque tube. A steel crosspiece is riveted to this latter upright, serving as a rest for the radius rods.

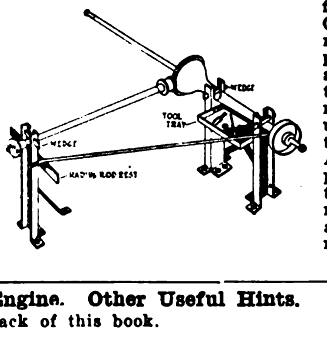


CHART NO. 848—Devices for Raising Car and Engine. Other Useful Hints.

*See advertisement of Continental Auto Parts Co. in back of this book.

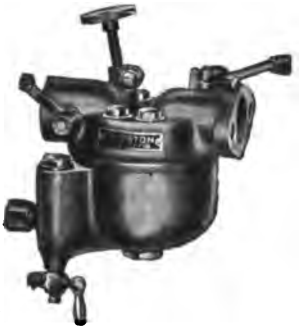


Fig. 80—The Kingston model "Y," see page 160 for a sectional view.

Carburetors.

Two types of carburetors are furnished on Ford cars:— the Holley, made by Holley Bros. Co., Detroit, Mich., and the Kingston, made by Byrne, Kingston & Co., Kokomo, Ind. There is very little difference in the adjusting of these two carburetors, but there is considerable difference in their repair, so they are here considered separately.

Dash Adjustment.

Both Holley and Kingston carburetors are of the automatic type, having but one adjustment,—the carburetor adjustment knob† is on the dash (fig. 81). Turning this knob to the right,—or in a clockwise direction—tends to give a weaker mixture and save gasoline. But, turning this knob to the left, opens the spray nozzle and gives a richer mixture, which makes starting easier. In fig. 81, the different positions are shown at A, B and C.

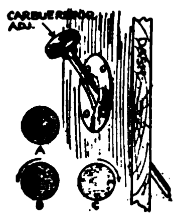


Fig. 81—Carburetor dash adjustment. A—is the position for correct mixture; B—for rich mixture; C—lean mixture. Adjustments in this direction saves gasoline.

Needle-valve Adjustment.

After the new car has been thoroughly worked in, a file mark or notch should be made on the face of this knob, so that the driver can determine the setting, even in the dark. (A) indicates the position at which the engine runs most satisfactorily. In cold weather, it will probably be necessary to turn the knob at least a quarter turn to the left, as at (B)—especially when starting.

As gasoline vaporizes more readily in warm weather, the driver will find it economical to reduce the quantity of gasoline in the mixture by turning the carburetor adjustment to the right (as far as possible without reducing speed) as indicated at (C). This is particularly true when taking long drives where conditions permit a fair rate of speed being maintained, and accounts for the excellent gasoline mileage obtained by good drivers.

Carburetor Adjustment.

The usual method of regulating the carburetor is to start the engine, advancing the throttle lever to about the sixth notch, with the spark retarded to about the fourth notch. The flow of gasoline should now be cut off by screwing the needle valve down (to the right) until the engine begins to misfire; then gradually increase the gasoline feed by opening the needle valve until the engine picks up and reaches its highest speed—and until no trace of black smoke comes from the exhaust. Having determined the point where the engine runs at its maximum speed, the needle valve binding screw should be tightened to prevent the adjustment being disturbed. For average running a lean mixture will give better results than a rich one.

*Starting the Engine in Cold Weather.

The usual method of starting the engine when cold is to turn the carburetor dash adjustment one-quarter turn to the left in order to allow a richer mixture of gasoline to be drawn into the cylinders; then hold out the priming rod, which projects through the radiator, while you turn crank from six to eight one-quarter turns in quick succession.

Another method of starting a troublesome cold engine is as follows: Before you throw on the magneto switch, (1) close throttle;** (2) hold out priming rod while you give crank several quick turns, then let go of priming rod (being careful that it goes back all the way); (3) place spark lever in about third notch and advance throttle lever several notches; (4) throw on switch (being sure to get it on side marked "Magneto"); (5) give crank one or two turns, and engine should start. After engine starts it is advisable to advance the spark eight or ten notches on the quadrant and let it run until thoroughly heated up. If you start out with a cold engine you will not have much power and are liable to "stall." The advantage of turning on the switch last, or after priming, is that when you throw on the switch and give the crank one-quarter turn, you have plenty of gas in the cylinders to keep the engine running, thereby eliminating the trouble of the engine starting and stopping. After engine is warmed up turn carburetor adjustment back one-quarter turn.

To Facilitate Easy Starting.

Some drivers make a practice of speeding up the engine by opening the throttle, just before stopping (by turning off the coil switch). This leaves the cylinders fully charged with gas. See bottom of page 158, left column.

Pulling out the priming ring, and thus causing a very rich mixture to be drawn into the cylinders, is another method of stopping the engine that will make it easier to start in cold weather. If tried in warm weather, it is apt to leave such a rich mixture in the cylinders that the engine will be hard to start within the next hour or two. Explanation of "Rich and Lean Mixtures" is given on pages 168 and 169. (Also, see page 489, on starting engine with the switch open.)

Kingston carburetor is shown in sectional view on page 160. This shows how the gasoline enters the carburetor, is vaporized in a current of air, and then passes through the inlet manifold to the engine in the form of an explosive mixture, which gives the power.

The hot air pipe, from the air intake of the carburetor to the exhaust manifold, is useful in summer as well as winter with poor gasoline (see page 155).

Float Level Adjustment of Kingston.

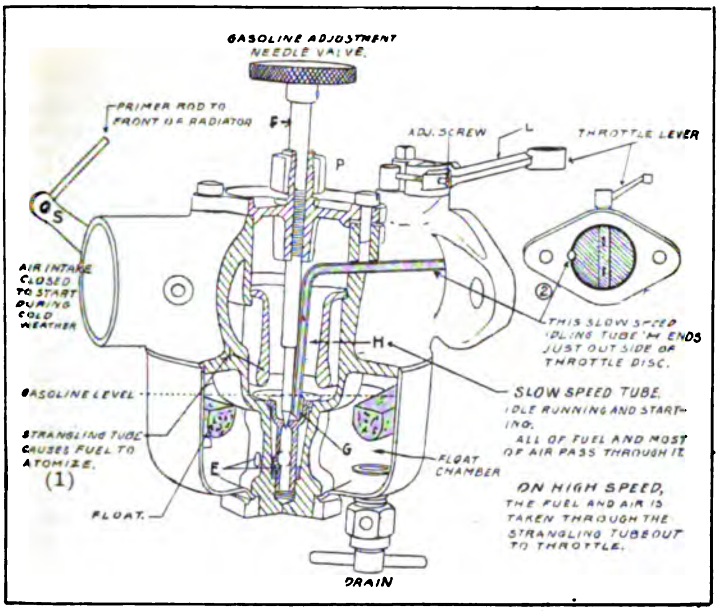
Model Y Kingston, used on 1918-14 Ford cars. Float should be set to show a clearance of 9/32 inch from top of the float to the top or face of the cup casting. (model L, 1915 same.)

Model L-2 Kingston. The action and the float setting of this carburetor is entirely different from that of the other two models. The float is hinged directly to the body, instead of in the cup, as in models Y and L. To test the level of the float, turn the body upside down and when properly set, it should show a clearance of 7/16 inch from the machined surface on the top casting to the top of the float, at a point directly opposite the point where the float is fastened to the body of the carburetor. (see chart 345 for level of float of Holley).

HART NO. 344—Carburetor Adjustments—Kingston. The same needle valve or dash adjustment pplies to Holley also.

†It is now a bent wire rod. *See also pages 170, 489, 158, 161 and 155.

*Throttle is never entirely closed. (see "throttle adjusting screw A," chart 345)


GASOLINE ADJUSTMENT NEEDLE VALVE.
PRIMER ROD TO FRONT OF RADIATOR
F
P
S
AIR INTAKE CLOSED TO START DURING COLD WEATHER
ADJ. SCREW
L
THROTTLE LEVER
②
THIS SLOW SPEED IDLING TUBE 'H' ENDS JUST OUT SIDE OF THROTTLE DISC.
H
GASOLINE LEVEL
SLOW SPEED TUBE. IDLE RUNNING AND STARTING. ALL OF FUEL AND MOST OF AIR PASS THROUGH IT.
STRANGLING TUBE CAUSES FUEL TO ATOMIZE.
(1)
G
E
FLOAT CHAMBER
ON HIGH SPEED, THE FUEL AND AIR IS TAKEN THROUGH THE STRANGLING TUBE OUT TO THROTTLE.
FLOAT.
DRAIN

Holley Model "G" Carburetor.

From the float chamber the gasoline passes through the ports (E) to the nozzle orifice in which is located the pointed end of the needle (F).

A drain valve is provided for the purpose of drawing off whatever sediment or water may accumulate in the float chamber.

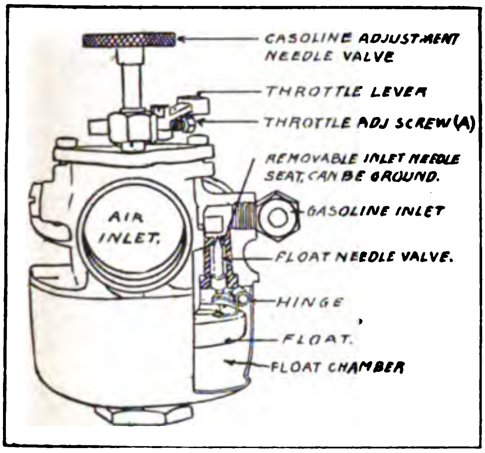
The float level is so set that the gasoline rises past the needle valve (F) and sufficiently fills the cup (G) to submerge the lower end of the small copper tube (H). Drilled passages in the casting communicate the upper end of this tube with an outlet at the edge of the throttle disk. (see 2.)

The tube and passage give the starting and idling.

The strangling tube (1) gives the entering air stream an annular converging form, in which the lowest pressure and highest velocity occur immediately above the cup (G); thus it is seen that the fuel issuing past the needle valve (F) is immediately picked up by the main air stream, at the point of the latter's highest velocity. Termed the venturi principle.

This gives thorough atomization of the fuel and results in very economical and powerful performance. **The lever (L)** operates the throttle.

For facilitating starting in extremely cold weather. A disk attached to lever S, with spring return, is connected to a priming rod. By closing this, an excess of gasoline is drawn into cylinders.



Holley Carburetor Needle Valve Troubles and Remedies.

Carburetors may leak from following causes:

(1) Sediment in fuel lodging on the needle valve seat, preventing needle from closing.

(2) Inlet needle or seat damaged or worn.

(3) Fuel level too high, flooding the nozzle.

These troubles may be overcome as follows:

(1) Thoroughly clean the fuel tank, pipe and carburetor, removing all sediment. After cleaning fuel system filter fuel through a clean piece of chamois.

(2) **Damaged float inlet needle:** Inlet needle and seat should be replaced if a ridge is worn on the tapered point, or if seat is scored; but in no case should a needle be replaced without a new seat, or vise versa.

To remove detachable seat, unscrew float chamber nut at bottom of carburetor, take off float chamber containing float and lever and inlet needle, then insert socket wrench as shown in fig. 1.

When installing new seat do not turn it up too tight, as this may leave a burr inside which will interfere with the movement of the needle. After installing the seat and new needle see that the latter works freely before attaching the float.

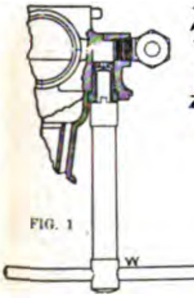


FIG. 1

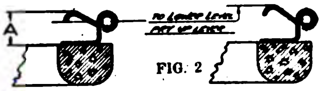


FIG. 2

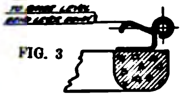


FIG. 3

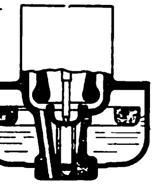


FIG. 4

Adjusting of Fuel or Float Level.

Attach carburetor to manifold and then take off mixing chamber cap by taking out screws. This will enable you to see the nozzle and fuel level. Connect the fuel line to the carburetor; turn on fuel; note where level comes. The level should be as shown in fig. 4.

Level too high, flooding the nozzle: Remove the float chamber and pry up the lever, as shown on fig. 2, until the level is correct. The **gasoline level** should be from 1/16" to 1/8" lower than the top of the nozzle—fig. 4.

Fuel level too low: Should the level be lower than shown in fig. 4, bend the tab on float lever (that the needle rides on), down toward the float, as shown on fig. 3. It is best to detach float and lever for this operation, by drawing out float lever pin. The distance from machined flange on the **mixing** chamber, to the top of float lever should be about 1/2" when float valve is closed.

Caution: It requires a bend of only 1/32 of an inch on the float lever in order to change the gasoline level 1/8 of an inch. **When setting float,** try to keep it at an angle, that is, the part opposite the float lever—so the pressure of the gasoline will assure a tight fit.

CHART NO. 345—Holley Carburetor also Used by the Ford Co.

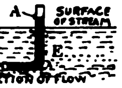
The Holley Co. (Detroit), also manufacture a Ford carburetor suitable for kerosene. See also page 160.

The Schebler Plain Tube Carburetor With Pitot Tube Principle.

This model is known as the "model Ford A" and differs from the average carburetor. It is a similar principle as shown on pages 176 and 177. Such moving parts as dash pots, metering pins for increasing the flow of gasoline has been eliminated—yet a rich mixture for acceleration can be obtained quickly.

Explanation of a Pitot Tube.

A Pitot tube is a very old instrument for measuring velocities of flowing streams of water. Invented by Henri Pitot in 1730. It consisted of a vertical glass tube with a right angled bend as shown at (E).



The impact of the flowing water against open end (F) of tube (E) caused a column to rise above the surface of the stream as at (A), and by this small difference in height, the velocity of the stream was calculated. A similar principle, but to provide air is embodied in the carburetor to be explained.

Schebler Plain Tube Carburetor.

Adjustments; there are two gasoline adjustments, one for low speed 4 to 5 m. p. h. up to the maximum without "loading" up or missing.

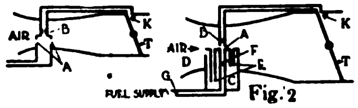


Fig. 2

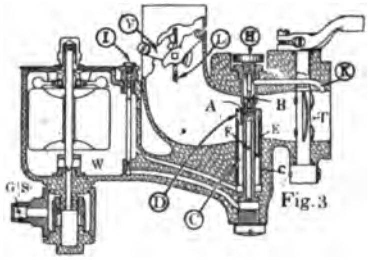


Fig. 3

I—high speed gasoline adjusting needle.
H—low speed gasoline adj. needle.
L—choker valve. T—throttle valve.
K—idle and low speed by pass.
D—Pitot opening.

Operation or Action.

The theory of operation is that gasoline and air obey the same laws of flow, therefore, if they are started at a common zero, the flow of fuel out of a nozzle inserted in and caused by a flow of air through a pipe or in a carburetor, a venturi will remain directly proportional. However, fuel in the liquid state does not flow until considerable head is produced, due to surface tension or capillarity. To break this tension, or holding, of the fuel in the jet, the high vacuum above the throttle is utilized.

Air flows into and through the choke or venturi tube in the direction of the arrow (fig. 2) but for idle speeds of the engine the velocity is too low to cause suction enough to break the surface tension at the main nozzle (A). An extension (K) is provided from the main nozzle to the space above or engine side of the throttle (T).

The size of this extension or passage is controlled at (B) by screw (H).

In operation the high suction above the throttle (T) breaks the surface tension in the main nozzle and causes fuel to flow through the extension (K) with some air which is drawn in through the main nozzle holes (A) at (B by H), the flow rate can be made to equal that which would be taken out of (A) if surface tension were eliminated. As the throttle is opened the increasing suction at the main nozzle cuts down the air bleed through the holes (A) and causes more fuel to pass through the extension (K) until that suction caused by the flow of air at main nozzle (A) equals the decreasing static suction above the throttle (T). Then fuel comes out of the main nozzle holes (A) into the main air stream. This also probably causes a slight reversal flow in the extension passage.

This combination produces a correct proportion of air and fuel through a very large range if the throttle is not thrown wide open from its closed position suddenly. When this happens the engine would lay down or miss six or seven shots and sometimes die completely.

To overcome this trouble an overflow well, or reserve chamber (O), is formed around the main fuel passage, whose top is integral with the main nozzle head and provided with a downstream pitot (D). From this head two acceleration tubes (E) extend to different depths into the overflow well (O) and discharge into the main air stream.

Pitot Supplies Air.

With the engine idling or running slowly the well (O) will fill up by means of the hole (F) in the main nozzle passage.

Upon suddenly throwing the throttle wide open the reserve supply of fuel is taken out the acceleration tubes (E) as well as from the main jet (A). This practically makes a temporarily large jet or nozzle until one of the tubes (E), is uncovered by the lowering of the fuel level in the well. Air then is drawn out through this tube and acts in opposition to the supply of air from the pitot (D). This opposition causes a gradually increasing suction in the well (O) and uniformly decreases the discharge of fuel therefrom out of the longer tube (E). This operation fills in the time element necessary for the main jet to resume its normal functions of delivering a thin mixture.

The tubes (E) also are made of varying lengths to hold a reserve supply of fuel in the well from some intermediate speed of, say, 15 m.p.h.

The pitot function is simply to provide air at sufficient pressure to force the fuel from the well and be inclosed in the carburetor. It so happens that in a stream of air the pressure head due to velocity is negative and exactly equal to the positive impact head due to the same velocity, therefore, the pitot hole, facing down stream, delivers air to the well at or very near atmospheric pressure.

All the fuel passes through the main adjustment (G), which is located at the float bowl and governed by screw (I), therefore, controls the whole range of the carburetor while still allowing the idle or low-speed adjustment to be changed with the condition of the engine or variations in engines of the same design.

Gasoline float level is 1 in. below top of bowl with needle seated.

Engine Troubles.

Engine fails to start; (1) lack of gasoline—see page 798; (2) no spark—see page 808. Additional reasons may be dirty magneto terminal, vibrators not adjusted properly. See pages 284 and 578 to 581.

Engine loses power; see pages 790, 626, 628 for poor compression; mixture not correct, see pages 169 to 171; valves need grinding; valve clearance not correct; **engine stops**—see page 578.

***Engine overheats**—see page 579 and 189. **Engine knocks**—see page 790, 635 to 639 and 580.

Engine misses explosion—see pages 579, 808, 234 to 236 and 169 to 171.

Popping in carburetor—lack of gasoline (see page 170); **black smoke**, too much gasoline; **blue or white smoke**, too much lubricating oil; **grey smoke**, excess of both—see page 169.

CHART NO. 346—Principle of a Plain Tube Carburetor with Pitot Principle Introduced.

A gas heated inlet manifold will save gasoline and assist carburetion—see pages 160 and 155.

***To thaw out a frozen radiator**—see pages 788, 579, 193.

*Auxiliary Air Valves.

The high cost of gasoline and the low cost of air has made many owners of cars wish that they could burn air instead of gasoline. While this is, of course impossible, it is still quite true that a much greater mileage per gallon of gasoline can often be obtained by burning the gasoline vapor more completely in the presence of additional air.

Complete combustion occurs when there is sufficient air mixed with the fuel to furnish enough oxygen to combine with all the fuel particles. When complete combustion is obtained, no smoke or carbon will be formed. Thus the use of auxiliary air valves may reduce the amount of carbon deposited in the cylinders.

The mixture of gasoline and air as it comes from the carburetor is often full of little drops of almost pure gasoline. These drops are simply burned in the cylinder, instead of forming an explosive mixture. as they would if the mixture were more perfectly vaporized. The admission of air into the side of the stream of gasoline vapor often serves to form whirlpools which churn the gasoline particles into a more perfect mixture with the air.

If your carburetor mixture is perfect then the air valve is unnecessary. Unfortunately most carburetors are far from perfect and the air valve under the control of the driver compensates for carburetor deficiencies. The air valve, in most instances increases the efficiency of any carburetor, if properly applied.

To determine if the auxiliary air valve is required, close the throttle and retard the spark until the engine runs as slowly as possible. Then adjust the carburetor until the engine runs smoothly and evenly on the least possible amount of gasoline.

Now take the car out on the road and, with the spark advanced and the car traveling at about twenty or twenty-five m. p. h., attempt to reduce the amount of gasoline by turning the carburetor dash adjusting knob.

If the amount of gasoline can be reduced without greatly affecting the power and speed of the engine, the fitting of an auxiliary air valve will be advantageous.

Types of Air Valves.

The type of air valve fitted should be one that supplies additional air at high speeds. But if, on the contrary, the engine requires a richer mixture at high speeds, when the carburetor is adjusted for good running at low speeds, then that type of air valve should be fitted that supplies air at low speeds, but is drawn closed by the suction at high speeds.

Correct adaption of the air valve to eccentricities of the particular engine and carburetor are necessary to get good results.

To obtain the best results from the auxiliary air valve, it should be easily controlled, preferably from the steering column. If it is operated from the dash, it will be little better than the carburetor adjusting knob which is already provided. In fact, the idea of the air valve is to bring the carburetor more completely under the control of the driver.

Fig. 1—Perhaps the simplest form of auxiliary air valve is that made by threading a Ford oil cup into a hole in the side of the intake manifold. A strip of brass about half an inch wide should be soldered to one side of the movable part of the oil cup, thus forming a lever by means of which the opening and closing of the air valve may be controlled. A hole may be drilled near the end of this lever, and a wire connected to the lever, this wire running through copper tubing or a *Bowden wire arrangement to the steering column. The end of the wire may end in a loop or be connected to a small lever to suit the convenience of the driver.

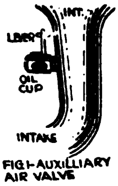


FIG.1-AUXILLIARY AIR VALVE

*Bowden wire is small, flexible, metallic tubing, with a strong but flexible wire running through it, (see T—page 173, fig. 3.) Can be obtained from motorcycle agents, as it is used on the control system of many motorcycles.

Fig. 3—Another simple form of air valve, which is more nearly airtight when closed, consists of a priming valve, screwed into an elbow attached to the intake manifold. A hole can be drilled through the handle of this priming valve for the attachment of the wire to the steering column control.

This air valve has the advantage that it can be used for priming in cold weather, or for introducing water or kerosene for loosening carbon deposits.

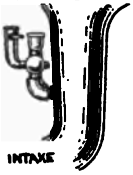


FIG.3-PRIMING VALVE

In winter, it is preferable to inject warm, rather than cold air into the manifold, and for this purpose it is often well to fit a soft copper pipe, (which can be wrapped around the exhaust pipe) to the air valve.

Fig. 2—An air valve made of standard quarter-inch pipe fittings and valve is also shown, and the end of the intake pipe is covered with a sheet iron sleeve, so that hot air will be drawn from the top of the exhaust manifold.

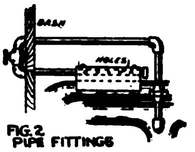


FIG.2 PIPE FITTINGS

Another form of air valve: which eliminates the use of moving parts, is as follows: One end of a copper tube is fastened by means of a brass coupling to a hole in the side of the intake manifold. The tube is then given four turns around the exhaust manifold near the point where the exhaust pipe is connected. The copper tubing is then led along the dash and up the steering column, ending in an air valve directly under the steering wheel. Of course, this device can be used for priming the motor or injecting carbon softening solutions.

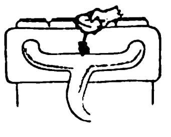
When first installed, this device made a whistling sound when the air valve was opened, but this was overcome by rounding off the edges of the air valve, and since then has given entire satisfaction.

The auxiliary air valve is most useful in hilly country, for then conditions vary most widely It is possible to use the air valve to make the engine act as a brake when coasting down hill. The admission of the air tends to cool the engine, so that the next hill will be climbed more easily. Opening the air valve also breaks the suction in the cylinders and keeps the oil from being drawn up and fouling the spark plugs when the engine is used as a brake on long hills.

A Primer.

For extreme cold weather a method of priming is shown. Take off inlet pipe and drill hole for ¼ inch pipe tap and fit a priming cock.

To operate, (1)—turn off switch. (2)—pour about a table spoonful of gasoline into intake through this cock. Keep an oil can filled for the purpose. (3)—close up cock, (4)—crank three or four times with switch off. 5—now turn on switch, open throttle and engine will start—see also page 156.



See also foot note bottom of page 153, (see page 735 for "super-heated" steam for carbon removal and page 823).

*Gasoline Tank Gauge.

A good idea for a simple gasoline gauge is to get a cheap 18 in. flat rule, marked in inches and fractions thereof. Coat it with plumbago by applying the domestic stove-polish brush. If you insert this rule vertically into the tank, right down to the bottom—the car being level—the gasoline will leave a mark on it. The quantity can be gauged as per marks on the rule as follows:

1 gal.	......$1\frac{17}{32}$ ins.	6 gal.	......$5\frac{29}{32}$ ins.
2 gal.	......$2\frac{9}{16}$ ins.	7 gal.	......$6\frac{3}{4}$ ins.
3 gal.	......$3\frac{1}{8}$ ins.	8 gal.	......$7\frac{11}{16}$ ins.
4 gal.	......$4\frac{11}{32}$ ins.	9 gal.	......$8\frac{25}{32}$ ins.
5 gal.	......$5\frac{1}{8}$ ins.	10 gal.	......$10\frac{1}{4}$ ins.

*See also page 823.

CHART NO. 347—Auxiliary Air Valves. Priming Methods. Gasoline Tank Gauge

Exhaust heated inlet manifolds are recommended—see page 155. **A Ford gasoline-kerosene carburetor** is illustrated on page 160. Air valves above from "Fordowner." *A recommended type of air valve is shown on page 735. fig. 12.

Control of Carburetor Mixture.

A saving in gasoline: All Ford users are acquainted with the peculiarity of the Ford carburetor, in which variation of the strength of the mixture is obtained by altering the size of the jet, the alteration being effected by screwing a vertical needle up or down. This needle is tapered at its lower end, and the tapered portion enters the jet orifice; consequently, as the needle is lowered the jet is closed; as the needle is lifted, the jet is opened and the size of the hole increased. This alteration is controlled by the driver through the medium of a rod which projects through the dash, per chart 344, the top end of the rod is fitted with a suitable device, for convenience when handling; the lower end is forked as per (D), page 160, and the two prongs of the fork fit into suitable holes in a disc on the top of the needle already mentioned.

If you are a motor-wise driver, you set that disc differently for varying conditions, turning it anti-clockwise for starting, clockwise when you have started, and still further clockwise when you have been running for, say 15 minutes. As the cool of the evening comes on, you will probably find it advantageous to turn the disc back again a little. In other words, you keep the disc as nearly as possible for maximum efficiency of the mixture under all conditions.

***The jet should be opened slightly so that sufficient gasoline is available for fast running,** while at the same time the mixture is too rich when running slow.

On the other hand, as the spark is advanced, the jet should be slightly closed and mixture weakened.

The increase of fuel for an increased throttle opening is not much; it is just sufficient to allow of the correct proportions of gasoline and air being provided when the engine is demanding its full supply of gas. It is a known fact that a weak mixture can be readily fired by a spark when fully advanced. The result is, an economy of fuel.

The conditions are always varying, and you cannot always be bending forward to twiddle that disc, and if you could your adjustment would not be fine enough, and it means fine adjustment to keep the mixture just right. If it is not just right, you will be simply wasting gasoline instead of using it economically as an ingredient in an efficient explosive mixture.

This device provides an accessible control which will enable you to set the disc anew whenever conditions indicate the need, and to set it to a really fine point of adjustment, so that the mixture will not be in the nature of a compromise.

A method employed (by an experimenter who is fond of tinkering), is similar to devices used on some of the other makes of carburetors and is nothing more than a **hand control** placed on the steering post as per fig. 82.

A steering column control as per fig. 5, page 173 is utilized, together with wire and casing (T), explained on the same page. A small lever is riveted and soldered to the carburetor dash control adjustment.

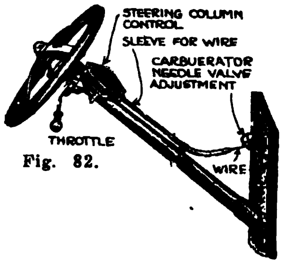


Fig. 82.

The fitting of the parts should be careful and accurate, so that there will not be the slightest play or lost motion.

If this device is used in conjunction with the throttle, as explained above, it is claimed that a saving of gasoline will be obtained, together with a cooler and smoother running engine. There are suitable graduations for different driving conditions, which the driver will soon learn, and the mixture can be made richer or weaker as required by the road driving conditions. Do not trouble, however, to experiment with this device unless you are a "fine point" driver as it will be of little assistance unless you study out the principle and know when and how to regulate the adjustment.

†More Miles Per Gallon.

There are three ways of obtaining more miles per gallon: (1) by increasing the efficiency of the engine; (2) by reducing engine and running gear friction; (3) and last, but not least, by skillful driving.

The efficiency of the engine can be increased by careful carburetor adjustment, which must be changed frequently, if the best possible results are to be obtained. Worn carburetor parts waste gasoline and should be replaced. Either an attachment for leading hot air to the carburetor, or a special manifold, which heats the vapor mixture after it leaves the carburetor, should be used to ensure complete vaporization of the fuel and give higher efficiency.

Carbon cuts down the efficiency of the engine and should be removed occasionally. Poor oil tends to form carbon, so good oil should be used, as it also causes less friction and wear.

Loss of compression, due to leaky piston rings or leaky valves will cause a steady loss of power, which must be compensated for by opening the throttle wider, thus wasting gasoline. Scored or worn cylinders will have the same effect. And the valve tappets should be adjusted, to provide the proper clearance as given on pages 94, 85 and 110.

Idling or running the engine while the car is at rest, or racing the engine unnecessarily, tends to waste fuel.

Good ignition is another essential in making the most ont of the fuel. Driving with a retarded spark tends to waste the power of the engine and causes overheating also.

Gasoline leaks from the tank, pipe line, or carburetor sometimes waste considerable gasoline and, as the fuel evaporates as fast as it drips, this loss of fuel is not always quickly noticed.

The most economical driving speed is about 20 miles per hour.

CHART NO. 348—More Miles Per Gallon. Fine Point Carburetor Adjusmtent.

†See also page 819.
*See page 798.
See page 809 for ether and gasoline.

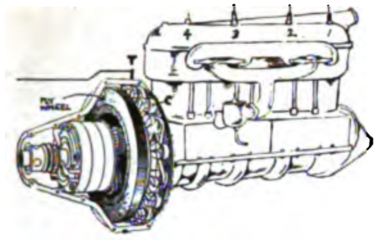


Fig. 86—An exaggerated line drawing showing the magneto location. Note coils (C) which are stationary and the magnets (A) which rotate. When fly wheel revolves, the 16 magnets (see fig. 91, chart 851) revolve in front of the 16 coils.

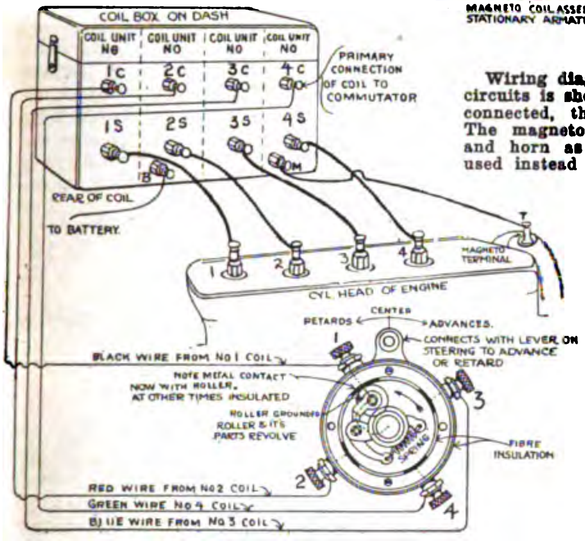


Fig. 87—Rear view of coil box and connections to commutator (primary circuit) and connections from coil box to spark plugs (secondary circuit). Note the color of wires are indicated on the primary circuit.

Firing order is 1, 2, 4, 3. Arrangement of terminals 1, 2, 4, 3 on commutator governs the firing order. Engine is made to fire 1, 2, 4, 3 instead of 1, 2, 3, 4. (see page 119.)

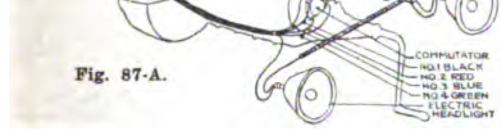
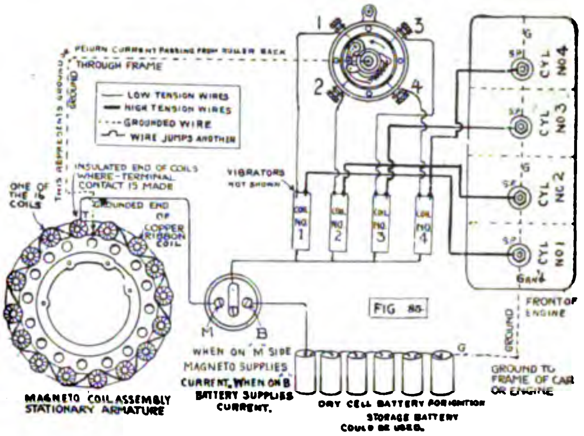


Fig. 87-A.

Fig. 87-A—The wiring of the earlier Ford is similar to above diagrams except this diagram shows the lighting and horn connections. The horn switch or button is on the steering post.


RETURN CURRENT PASSING FROM ROLLER BACK THROUGH FRAME
THIS REPRESENTS GROUND
GROUND
LOW TENSION WIRES
HIGH TENSION WIRES
GROUNDED WIRE
WIRE JUMPS ANOTHER
1
2
3
4
INSULATED END OF COILS WHERE TERMINAL CONTACT IS MADE
ONE OF THE 16 COILS
T
GROUNDED END OF COPPER RIBBON COIL
VIBRATORS NOT SHOWN
COIL NO 1
COIL NO 2
COIL NO 3
COIL NO 4
SP
G
CYL NO 4
CYL NO 3
CYL NO 2
CYL NO 1
FIG 85
M
B
WHEN ON 'M' SIDE MAGNETO SUPPLIES CURRENT, WHEN ON B BATTERY SUPPLIES CURRENT.
FRONT OF ENGINE
GROUND
GROUND TO FRAME OF CAR OR ENGINE
MAGNETO COIL ASSEMBLY STATIONARY ARMATURE
DRY CELL BATTERY FOR IGNITION STORAGE BATTERY COULD BE USED.

Ignition Circuit.

Wiring diagram showing path of primary and secondary circuits is shown in fig. 85. Although dry cells are shown connected, they are not supplied as regular equipment. The magneto alone supplies current for ignition, lights and horn as per fig. 87-A. Storage batteries could be used instead of dry cells and connected in place of same on the (B) side of switch (see (B) rear of coil box, fig. 87 where to connect one terminal of battery if used.) The other terminal is grounded. If storage battery is only 6 volts, (which is the usual voltage,) then it could be used only for ignition. To use for lights ignition and horn it would be necessary to either use a 9 volt battery or use 6 volt lamps. Ford cars are fitted with 9 volt lamps as regular equipment.

Primary Circuit.

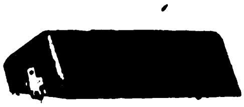
When switch is on (M) or magneto side, the current would be supplied by magneto. The current travels from magneto terminal (T) to switch thence through primary winding of coil to insulated terminal post (1, 2, 3 or 4) on commutator, thence through metal part of roller through ground or metal part of engine, back to grounded end of magneto coil. The commutator makes contact with one of the 4 insulated posts or contacts as the roller revolves.

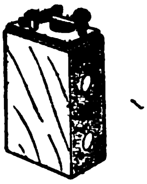
Secondary Circuit.

The current is intensified in the secondary winding of coil and travels from coil unit 1, 2, 3 or 4 in whch the commutator makes contact, to the spark plug (SP.) Note heavy lines, indicating high tension current. (see pages 226 and 220 for principle.)

The Coil Box.

Fig. 88—The coil box contains 4 high tension (vibrator type) coil units. The units can be removed from the box in case one is damaged. Connections to coils are in the rear as shown in figs. 87 and 87-A.





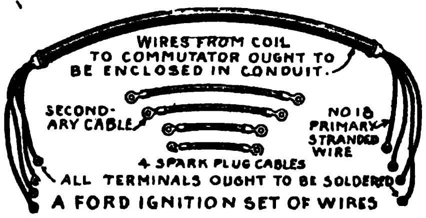
Coil unit: Note contacts on side.

CHART NO. 849—Ford Electric System and Wiring Diagrams.

Ignition timing of the Ford—see page 316. See page 864-A for Electric System of Ford enclosed cars.

Size of Wires.

The wires running from the secondary or high tension connections of the coils to the spark plugs are called secondary cable wires. Cable to No. 1 plug is 15 inches long. No. 2 cable is 11½ inches long. No. 4 cable is 8 inches long. No. 3 cable is 8 inches long.


WIRES FROM COIL TO COMMUTATOR OUGHT TO BE ENCLOSED IN CONDUIT.
SECONDARY CABLE
NO 18 PRIMARY STRANDED WIRE
4 SPARK PLUG CABLES
ALL TERMINALS OUGHT TO BE SOLDERED
A FORD IGNITION SET OF WIRES

**The size of wire running to the commutator, is No. 18 B and S gauge (stranded wire, see page 240).

If the latter wires are run in non-metallic conduit or circular loom (see page 241) the liability of short circuits and oil soaked wires will be greatly lessened. There are now 5 wires; one for light.

All wires ought to have terminals soldered on to the ends and all connections made as explained on page 240 and 427.

Dry Cells for Starting.

(B) side of switch can be used for batteries (dry or storage) for starting and after starting the switch is placed on (M) or magneto side (see fig. 85.) The Ford Co. claim however, the magneto gives current at a very low speed and batteries are not necessary. (If dry cells are used, use 5 or 6.)

Storage Battery for Ignition and Lights.

Can be connected in place of dry cells as shown in fig. 85. (also see chart 358.)

In connecting a storage battery the **battery terminal should never be connected to the magneto terminal** post on dash, as this will demagnetize the magnets.

To Set the Time of Spark.

See page 316. Note the No. 1 piston is placed ⅛ inch down after top of compression stroke, and roller on commutator is just starting to make contact with No. 1 cylinder. The commutator housing is retarded.

*Commutator Troubles.

If misfiring occurs when running at high speed, inspect the commutator. The surface of the circle around which roller travels should be clean and smooth, so that the roller makes a perfect contact at all points. If the roller fails to make a good contact on any one of the four contact points, its corresponding cylinder will not fire. In case the fibre, contact points and roller of the commutator are badly worn, the most satisfactory remedy is to replace them with new parts, or probably the trouble is caused by short-circuited commutator wires. The **spring should be** strong enough to make a firm contact between the roller and contact points even though slightly worn or dirty. (see fig. 13, page 241.)

Other causes of misfiring may also be due to an improperly seated valve, or short circuit in the commutator wiring.

Weakness in the valves may be easily determined by lifting the starting crank slowly the length of the stroke of each cylinder in turn, a strong or weak compression in any particular valve being easily detected. It sometimes happens that the cylinder head gasket (packing) becomes leaky—permitting the gas under compression to escape, a condition that can be detected by running a little lubricating oil around the edge of the gasket and noticing whether bubbles appear or not. Another source of leakage is around spark plugs. Test same way (see page 233).

How a short circuit in commutator wiring may be detected: Should the insulation of the primary wires (running from coil to commutator) become worn to such an extent that the copper wire is exposed—the current will leak out (i. e., short circuit) whenever contact with the engine pan or other metal parts is made. A steady buzzing of one of the coil units will indicate a "short" in the wiring. When driving the car the engine will suddenly lag and pound on account of the premature explosion. **Be careful not to crank the engine downward against compression when the car is in this condition,** as the "short" is apt to cause a kick-back.

Parts of commutator which are most apt to get out of order are; the roller, the spring, or the fiber lining and contacts in the commutator shell. (see fig. 89, chart 349).

Cold weather effect on commutator: It is a well known fact that in cold weather even the best grades of lubricating oil are apt to congeal to some extent. If this occurs in the commutator it is very apt to prevent the roller from making perfect contact with the contact points imbedded in the fibre. This makes difficult starting, as the roller arm spring is not stiff enough to brush away the film of oil. To overcome this, as well as any liability of the contact points to rust, we recommend a mixture of 25% kerosene with the commutator lubricating oil, which will thin it sufficiently to prevent congealing, or freezing as it is commonly called. You have probably noticed in starting your car in cold weather that perhaps only one or two cylinders will fire for the first minute or so, which indicates that the timer is in the condition described above and as a consequence a perfect contact is not being made on each of the four terminals.

Removing Commutator.

Remove cotter pin from spark rod and detach latter from commutator. Loosen the cap screw which goes through breather pipe on top of time gear cover. This will release the spring which holds the commutator case in place and this part can be removed. Unscrew lock nut; withdraw steel brush cap and drive out the retaining pin. The brush can then be removed from the cam shaft.

In replacing the brush: reinstate so that the exhaust valve on the first cylinder is closed when the brush points upward. This may be ascertained by removing valve door and observing operation of No. 1 valve.

The commutator is to set 2½" from the center of the commutator case spring cap screw to the center of the commutator case pull rod when the spark lever is fully retarded (up as far as it will go). The case should be set by the spark lever on the steering column to take up any lost motion. The adjustment is made by turning the rod in or out of the ball socket joint. If this adjustment is inadequate, bend the pull rod.

HART NO. 350—Commutator Troubles. Size and Colors of Wire. Dry Cells and Storage Battery onnections. Setting the Time of Spark

---

*See fig. 89, page 805 for commutator construction. **See page 808 color of wires.

The Commutator

Is similar to the type explained on pages 225 and 222. fig. 2. It is placed on the end of the cam shaft, that is, the roller mechanism is attached to end of cam shaft and revolves with it, therefore the roller revolves ½ the speed or revolutions of the crank shaft. The roller makes contact with the **insulated** contact points of which there are 4 and which do not revolve. When roller comes in contact with one of the 4 insulated contact points, the coil unit connected with it becomes operative. As roller leaves contact, coil becomes inoperative.

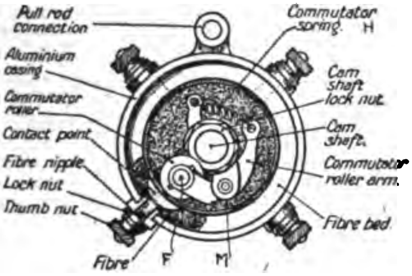


Fig. 89. The commutator.

To advance or retard time of spark, the housing is connected at "pull rod connection" with spark lever on steering wheel. See fig. 87 and note position to move to advance or retard. See page 222.

The Magneto

Supplies current for ignition, lights and horn as per fig. 87A. It is different from the usual type magneto.

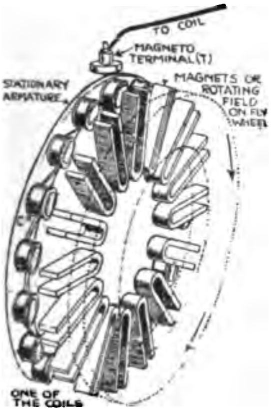


Fig. 91. Note the 16 magnets which revolve directly in front of the coils, also see page 265.

Magnets: instead of the horse shoe magnets being placed over the pole pieces and armature revolving therein note the position of magnets and coils in fig. 91. The magnets are called the rotating field.

The armature in this instance is stationary and consists of 16 coils* of thin copper tape wrapped over soft iron cores.

The consecutive coils are wound in opposite directions and are connected in series (see fig. 90.) The first coil terminal (to the left) in fig. 90, is connected to magneto terminal. The end of the 16th coil is grounded to iron frame which supports them.

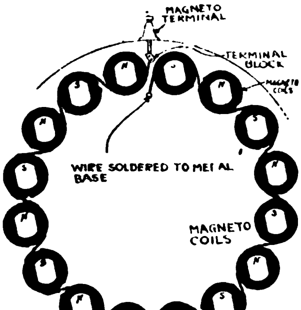
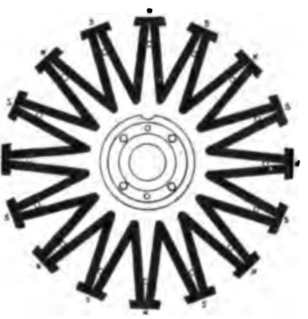


Fig. 90. The armature which is stationary.

The current generated is low tension, alternating, as explained on page 265. This low tension current is transformed to a high tension current through coils, fig. 88.

****Voltage** varies from 8 volts, lowest speed, to 25 or 30 volts at highest speed. Normal being about 18 to 20 volts at average speed.



†Fig. 91A. The magnet poles are placed like poles together and are mounted on flywheel.

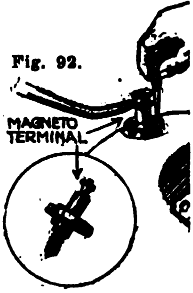


Fig. 92.

Dirt on the magneto terminal contact will cause dim lights and misfiring. It can be removed and cleaned.

**Cause of Weak Magnets.

(1) Dirty contact as per fig. 92.

(2) End play in bearings, caused by worn crank shaft bearing will permit magnets to rotate at too far a distance and current will be weak.

(3) A grounded magneto coil will weaken current.

‡Testing for Grounds.

In magneto coils; connect 5 or 6 dry cells to a 6 volt lamp (fig. 93). Attach one end of terminal from lamp to magneto terminal. (T). Then unsolder the grounded end of winding at coil C-2. With other wire from battery touch the iron frame (Y); if the lamp lights, then somewhere there is a ground of one of the spools in contact with the frame.

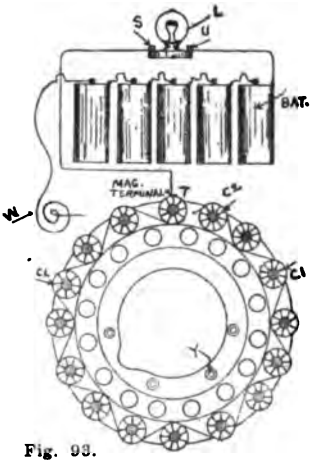


Fig. 93.

The next step will be to find out in what particular portion of the winding, the ground exists.

Attach the test wire (W) to metal part. This can be easily done by inserting the end, under nut (Y) or temporarily making a soldered joint at the point where permanent ground was formerly attached, if there is a ground, lamp will then light.

Loosen the coils one at a time and shake vigorously, or move up and down, this will cause the light to flicker—or go out and on when you reach the coil or section where the ground is located.

The ground can sometimes be removed by cleaning out dirt and metallic particles and revarnish with a special oil-proof varnish which can be obtained of Ford agents. Common shellac will not do.

Note—Illustration shows coil plate reversed. Bolt holes and recess for cam shaft should be on top as shown in fig. 85, page 803.

*Dead Points.

On the older model Fords which did not have the ¾ inch magnets, there were certain dead points where, if spark lever was placed in certain notches in quadrant, the engine would not respond with increased speed. On the late magnetos as the magnets pass from one end to the other as it revolves there is no dead point—see below and page 265.

CHART NO. 351—The Ford Magneto. Testing Magneto Coils.

---

*Note; while illustrations show magneto coils as being round, they are now made oblong, with oval pole pieces, so that as soon as the magnets pass away from one pole, they begin to influence the next—thus there are no "dead points." **Varies according to distance between magnets and coil cores and strength of magnets, see page 864-J. †**See page 303, how to test polarity of** a magnet. Before assembling, test magnets and chalk-mark N poles. After assembling, test correctness, by passing compass around fly wheel, close to outside of magnets—the needle should reverse as each pair of poles is passed. If placed wrong, needle will turn cross-wise and tremble. ‡See pages 864-J. 806.

†Indications of Weak Magnets.

(1)—Dim lights. (2)—Frequent backfires, or explosions in the muffler when running—possibly blowing the muffler up.

The magneto is often blamed for trouble that lies elsewhere in the electrical system. A weak current will often be caused by dirt or waste collecting beneath the terminal contact spring on the crankcase cover. To clean; remove the three screws holding the binding post, remove the post and spring, and clean as per fig. 92, chart 351.

Check up the wiring for short circuits or grounds.

To reach the magnets it is necessary to remove the engine from the car. The common method of doing this is to remove radiator, dash and steering gear and lifting the engine out complete. By the method herein outlined the base of the engine is left in the chassis and the dash and steering gear are left undisturbed. Two experienced men can readily remove an engine and place it on the bench in 30 min. by this method.

*To Remove Engine.

1–Drain radiator.

2–Remove four bolts at universal joint.

3–Remove rear spring shackles and pull rear axle back. (The rear of the car must first be blocked up.)

4–Disconnect radiator stay rod.

5–Remove the two bolts holding the radiator to the frame and remove the radiator.

6–Unsnap cammutator and place it to one side.

7–Remove spark plug wires.

8–Shut off the gasoline and remove the feed line from the carburetor.

9–Disconnect the exhaust manifold from the exhaust pipe and remove both intake and exhaust manifolds from the engine.

10–Removo fanshaft bracket and timing gear case.

11–Remove the two bolts holding the pans to each side of the base and knock the pans down out of the way.

12–Remove the base bolts.

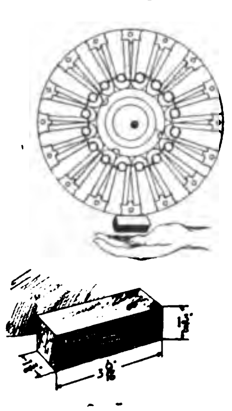
13–Remove the transmission case after loosening the reverse, low and brake transmission bands.

14—Lift the engine from the frame and place it on the bench. The lifting may be done with a hoist. It is quicker and easier, however, if three men take a hold of it and lift it out by hand. One should straddle the engine at the rear and the other two should be at each side at the front.

Tearing Down the Engine and Testing.†

1–Clamp the engine on the bench.

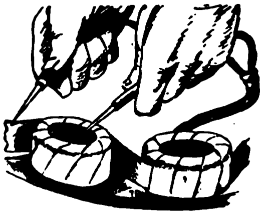
2–Test the magnets on the flywheel, as shown in fig. 2. The block of steel should just hang by a corner. The weight of this test block happens to be the same as that of the Ford camshaft gear. Failure to hold indicates weak magnets.



3–Remove the bolts holding the flywheel and transmission to the crankshaft.

4–Remove the flywheel, magnet and transmission unit, placing it face down on the bench.

5–If trouble is suspected in the magneto coils, these may be tested, as shown in fig. 3. The two test points are connected to a 110-volt alternating current line, per fig. 33. The main ground of the coils is disconnected and each coil tested for shorts, grounds or open circuit. (see also fig. 98, chart 351.)



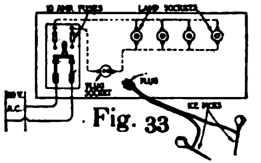


Fig. 33

6–Chisel the heads from the ends of the brass magnet retainng screws at the rear of the flywheel; when reassembling use new screws.

7–Turn the fly wheel transmission assembly over and set it upright in a square box placed on the bench.

8–Remove the wires holding the central magnet - retaining bolts.

9–Using a bit brace screw - driver, unscrew the outside magnet screws.

10–Using a bit brace socket wrench unscrew the central retaining bolts. Clean all parts.

Fig. 33 shows a testing outfit using 32 c. p. carbon lamps.

Building Up the Magnets.

1–Place the new magnets on the flywheel in the same order that they were in the box that they were shipped from the factory—**that is, so that the legs that do not attract each other are together. This means that like poles, or N&N and S&S poles are placed together.** (see fig. 91-A).

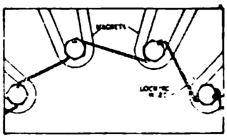


Fig. 5—Method of locking bolts by running a wire through the heads

2–Catch all the central retaining bolts in place but do not tighten.

3–Slip the outside spools under the magnet ends

4–Drop the magnet clamps onto the magnet ends and catch the brass screws into their threads.

5–Using a brace screwdriver, bring all of the screws down snug.

6–Pinch the ends of the magnets in with a pair of pliers until the sides of the magnets rest against the spacer on the clamps.

7–Tighten the outside brass screws.

8–Tighten the central retaining bolts.

9–Using (stovepipe or brass) wire, lock the central bolts in position. The wire should be inserted as shown in fig. 5, (when holes are about in position shown) as this creates a tendency to tighten instead of loosen the bolts.

10–Knock the four corners of each magnet clamp down over the magnets, so that they cannot interfere with the coils later.

11–Turn the assembly over and head the brass screw at the rear of the flywheel. Before assembly, the engine should be inspected for loose or worn bearings and if any are found they should be cleaned and adjusted.

†Assembling the Magneto.

1–Replace the flywheel-transmission assembly onto the crankshaft flange and secure it with two

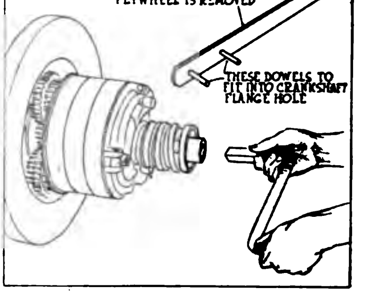

CRANKING BAR WHEN FLYWHEEL IS REMOVED
THESE DOWELS TO FIT INTO CRANKSHAFT FLANGE HOLE

Fig. 4—Cranking the engine with the transmission in place

PART NO. 352—Testing and Fitting Magnets. Testing Weak Magneto Coils—Ford Magnets. ing and Disassembling Engine. *See also, page 783. †See also, page 864-J. (Motor World.)

—continued from chart 352.

opposite flange bolts. Draw these bolts up snug.

2–Using the crank, as shown in fig. 4, turn the flywheel and note whether the magnets interfere with the coils. The magnets are set 1/32" from coils.‡

3–Replace the two other flange bolts.

4–Tighten all the flange bolts. A short piece of round stock, wedged through one of the holes in the coil flange and caught behind the magnets, holds the crank so that the bolts may be drawn tight.

5–Again using the crank as shown in fig. 4, crank the engine quite fast. While cranking, short circuit the magneto contact point with the cylinder using a screwdriver. A fat blue spark shows the magneto to be O. K.

6–A putty knife may be used as a gage for testing this distance. It may be found necessary to shim up the coil-supporting flange.

7–Place the locking wires in the crankshaft flange bolts as explained on page 806.

Replacing the Engine.

Before replacing the engine in the base, the base should be thoroughly cleaned. The rivets holding the supports to the base should be tested to see that they are tight. All bolts should be inspected.

1–Place the standard Ford felt packing on each side of the engine base, setting it in heavy oil.

2–Lift the engine up and set it in place. Be careful not to slide it around any more than necessary. Three men can do this easily.

3–Line up the holes in the base with a small drift.

4–Replace the front gear cover.

5–Drive all the base bolts through their holes, from the bottom up, and catch the nuts onto the threads. Two men, one with a speed wrench on the nuts and the other holding the bolts, can quickly fasten the engine to the base.

6–Slide the transmission bands in place.

7–Bring the lugs all together at the top and wire them together tightly with a single strand of stovepipe wire, or use a clamp similar to that shown in fig. 16, chart 324.

8–Place short lengths of felt gasket at A, B and C, as shown in fig. 6. Place ⅜-inch asbestos wicking and grease in the corners at D and E.

9–Then place the standard Ford felt transmission gasket in place. The double thickness felt and the asbestos wicking stop up the points that tend to leak.

10–Slide the transmission housing in place. Using a screwdriver, pry the bands into place.

11–Knock the housing down flush and tighten the two rear retaining bolts.

12–Using a thin socket, or check nut wrench, tighten the transmission bands.

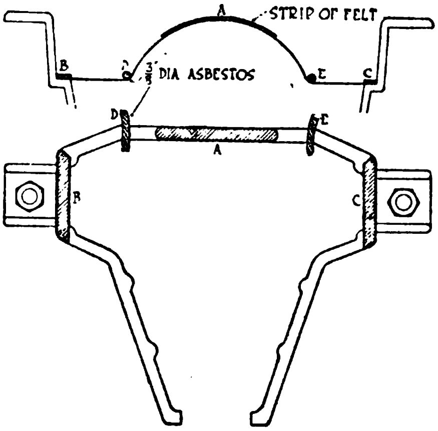


Fig. 6—Method of packing all joints to prevent leakage of oil.

13–Replace the balance of the housing bolts and bring them up snug.

14–Slide the rear axle and drive shaft back into place and secure it there.

15–Assemble the engine fittings, such as fan, commutator, wiring and manifolds.

16–Replace the radiator assembly hood and floor boards.

Later Magnets ¾ Inch.

To install ¾ inch magnets of the latest type so electric lights can be used; as the crankcase and the transmission cover are similar, the necessary parts include No. 3250-D magneto coil assembly, one set of ¾ inch magnets, sixteen magnet clamps No. 3277, and sixteen magnet clamp screws. (Former magnets were ⅝ inch.)

*Remagnetizing Ford Magnets.

The usual and proper method to remedy weak magnets is to replace them with new ones. The Ford Co., do not advise everyone to attempt this work. This however necessitates taking down engine and then reassembling. This makes a costly job and is a big job. Therefore different methods will be given to recharge magnets without removing from car.

Charging with storage batteries: Five or six, 6-volt storage batteries should be about right. Refer to fig. 7.

To prepare the magneto for recharging, first disconnect the wire (A) which goes from the magneto terminal on the transmision cover to the coil on the dash.

Next remove the transmission cover (B) so you can look at the magneto. Locate the brass studs on the rim of the flywheel which holds the magnets in place, and have some one turn over the engine very slowly until one of these brass studs is in line with an imaginary line drawn about 1 in. or so from the magneto terminal, to the left of the latter and paralleling the frame. Another way is to place an ordinary small compass on the transmission cover about 1 in. from and to the left of the magneto terminal, at the same time turning the engine slowly until the needle of the instrument is parallel with the engine.

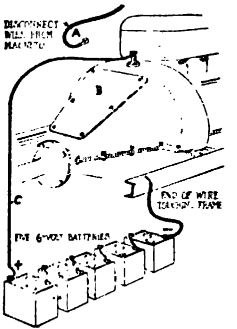


Fig. 7.

The north pole end of the needle should point towards the engine when in this position.

Connections; Connect a wire from positive (+) terminal of the battery to the magneto terminal on engine, as shown at (C).

Next connect a wire from the negative terminal on battery, and make and break the circuit by striking the free end of the wire on some metal part of the engine.

Permanent connection should not be made, but only thirty or so momentary contacts, which, it is said, will reacharge the magnets much more satisfactorily than if permanent contact is made. (Motor Age.)

*Other sources of electric supply for charging the magnets are shown below and on next page.

Dry cells can be used if necessary. Use 48 connected in series-multiple as shown in fig. 4. Connect positive (+), or carbon poles with terminal.

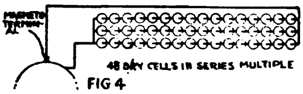


FIG 4

—continued on next page.

CHART NO. 353—Ford Magneto Testing—continued. **Remagnetizing Magnets. Replacing the Engine.**

***A magnet remagnetizer** for Ford magnets is advertised in the back of this book. See also, pages 819, 864-J.

‡See also, page 864-J.

—continued from chart 353.

Resistance wire; use 18 ft. nichrome No. 16 wire or 8 ft. of No. 18. If German silver, use 35 ft. No. 16 or 22 ft. No. 18.

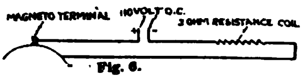


Fig. 6.

110 volt direct current: to use it will be necessary to use a resistance lamp bank, per fig. 5. Use twenty eight 32 c. p. carbon filament lamps. Connect positive pole with magneto terminal. Connected as shown, gives 27½ volts. To find positive pole, or polarity of any circuit—see page 452. (From Automobile Dealer and Repairer.)

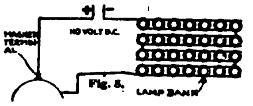


Fig. 5.

Ignition Troubles.

We have dealt with magneto troubles. We will now take up the coils and spark plugs.

Although this matter has been fully treated on page 236 and under heading "Digest of Troubles" (see page 578) we will touch on a few of the important points here.

Coil Units.

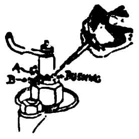
The four coil units on the Ford are contained in a metal box with a slanting cover (see fig. 88, chart 349) which enables them to be taken out of the box, without removing it from the dash. Some of the 1914 and 1915 metal coil boxes had straight covers, but when this type are used on a cowl dash, (1916 or 1917 body,) the units cannot be taken out, without taking the box off the dash.

The earlier wood box coils, were much inferior to the present type, and the Ford Motor Company makes an exchange proposition on these wood box coils which should be carefully considered before replacing defective coil units in wood box coils or installing new points.

Missing of Explosion.

Troubles due to the commutator, magneto terminal, weak magnets or grounded magneto coils, was treated on pages 804 to 806. Other causes, are spark plugs and coil vibrators.

Spark Plug Cause of Missing.



See page 233.

The first and most probable cause of missing is due to the spark plug points being set **too far apart** or **not far enough**—for instance if set too close there will be a tendency to miss at slow speed; if **set too far apart** missing will occur frequently. (see pages 233 and 299.) The spark plug may have become **fouled** from too much oil, which is common trouble—see pages 235, 237.

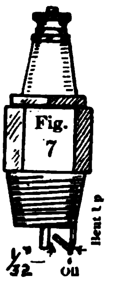


Fig. 7

Spark plug on the Ford is a ½ in. pipe thread, long body per page 238.

Gap should be 1/32 in. and if point is bent as shown the oil will have a tendency to drip off (see pages 233, 236 for testing a spark plug. **A worn dime** makes a good gage, as shown in fig. 11.

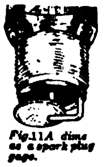
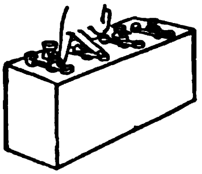


Fig.11A dime as a spark plug gage.

Coil Vibrator Points.

Too close contact between adjusting screw and vibrator will cause tungsten points to pit, which results in sticking and frequently burning away the tungsten and often putting the coil out of action and invariably causes missing.

This may be remedied by cleaning the points with fine emery cloth, or as explained on page 234, or by the use of a fine jewelers file which is made for the purpose. But is is advisable to be very careful and file flat. (see also page 809.)



To test the vibrators of a coil see page 286.

When "direct" current is used for ignition such as a storage battery or "direct" current dynamo, the tungsten points on a coil pit up very bad much more so than on an alternating current magneto. That is why a magneto interrupter point wears longer. Alternating current is much easier on tungsten points because the current is being constantly reversed from negative to positive or positive to negative. (see page 284 and last three paragraphs in chart 117).

Too high a voltage or excess of current will cause excessive sparking and will pit the points and cause them to stick or weld together.

Adjusting Vibrators.

With the spring held down, the gap between the vibrator points should be slightly less than 1/32 inch. Then set the lock nut so that the adjustment will not shake loose. Each coil unit should be adjusted to take about 1½ amperes, as measured by an ammeter. (see pages 234 and 236.)

Hard starting due to vibrator adjustment. If there is **too much tension** on the vibrator springs, the weak current generated by the magneto at cranking speeds will not be sufficient to cause the vibrators to buzz and it will be difficult to start the engine. **Too little tension** will not let the vibrators **respond** quickly and the engine will run unevenly.

A Defective Coil Unit

Can be detected by noticing if the vibrator buzzes without producing a spark at the plug. Then the suspected unit can be exchanged with another unit to make sure that the trouble is actually in the coil unit. A punctured condenser is indicated by a heavy spark at the vibrators and a weak spark at the spark plug.

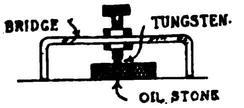
If the engine has a tendency to miss when driving over rough roads, this may be due to the coil units not fitting tightly in the coil box. The bouncing of the car makes the coil units touch the metal cover of the box and causes misfiring.

Sometimes, misfiring is due to the wooden lining of the metal coil box being damp and allowing the electric current to leak across from one terminal to another.

HART NO. 354—Remagnetizing Magnets—continued. **Ignition Troubles.**

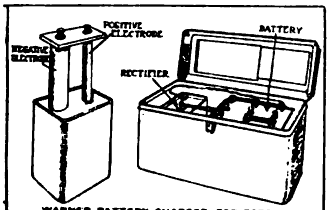
**Dressing Vibrator Points.

The coil point screw is clamped, by means of two nuts, to the center of the metal strip. The strip is moved forward and backward over the oilstone, thus securing a true surface on the tungsten point, which makes it last much longer without grinding. A flat jewelers file is often used also.

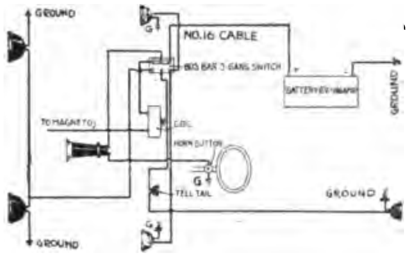


A Battery Charger.

A battery charger illustrated in Fordowner recently is shown in illustration. With this device the alternating current is rectified to direct current. The magneto is intended to supply the current for charging. The rectifier and battery are placed in a battery box on the running board.



WARNER BATTERY CHARGER, FOR FORDS
The Ford magneto may be used to charge storage batteries for the lighting system, by the use of this rectifier



Electric Lighting.

Although this subject is treated on page 812, this illustration which is a good example, recently appeared in Automobile Dealer and Repairer, and reproduced here. Note the completeness of the details and layout. A 100 ampere hour, 6-volt battery is used, which can be placed in a metal battery box located on the running board

Of course, the battery must be recharged when exhausted. If nitrogen, 6 volt lamps are used the amperage used per hour would be about 6½ amperes, therefore battery would give approximately 15 hours actual service. If spot light is used it will take 2 amperes more.

Ether, Picric Acid and Gasoline.

Q.—Can ether or picric acid be used for increasing power for racing? A.—Yes, nitrous ether has been used but is dangerous.

Nitrous ether is purchased in glass tubes and is put on ice at least 8 hours before attempt to handle, as heat from palm of hand will explode it and the glass is liable to put your eyes out. Mix one ounce to five gallons gasoline and you may have to add a little more gasoline or a little more ether to get the best results. **Ether you buy in pound cans is suitable for easy starting in cold weather,** by mixing half ether and half gasoline and put it in a small tank on dash, using a small priming pump to squirt it in the intake pipe. This ether can be handled without danger, as long as it is kept away from a flame.

Picric acid; put one pound of picric acid in a glass bottle and fill with gasoline or alcohol, keep in a cool place, stir twice a day for one week before using. The picric acid will not all dissolve, but pour out all the liquid, straining it through a fine seive and mix the same proportion as you do ether. You can use both together by equally dividing them. There is one point to watch closely; don't get mixture too rich. Picric acid is injurious to engine and will increase heat.

Miscellaneous Electric Systems.

*The Master Vibrator

Is a single coil (high tension), connected in series with the ignition system as explained on page 232 and illustrated in fig. 103 below. It improved the earlier wood box coils much more than it aids the latest metal box coils having tungsten points. With this system of ignition, but one vibrator is used, see page 232 for the general principle. The same commutator and other parts of the coil system are used, with the exception that the vibrators are short circuited by pieces of wire, as shown in fig. 103, and fig. 6, page 264. (The master vibrator is not supplied by Ford Co.)

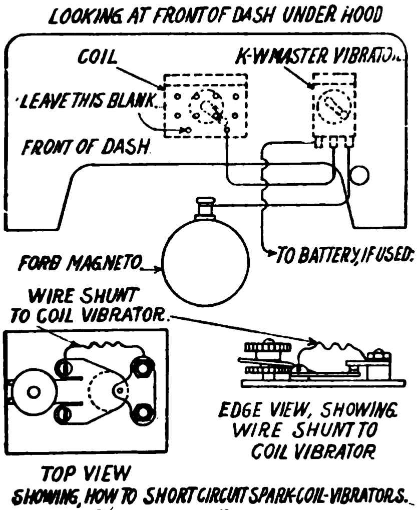

LOOKING AT FRONT OF DASH UNDER HOOD
COIL
K-W MASTER VIBRATOR
LEAVE THIS BLANK
FRONT OF DASH
FORD MAGNETO
TO BATTERY, IF USED.
WIRE SHUNT TO COIL VIBRATOR.
EDGE VIEW, SHOWING WIRE SHUNT TO COIL VIBRATOR
TOP VIEW
SHOWING HOW TO SHORT CIRCUIT SPARK-COIL-VIBRATORS.

Fig. 103.—The master vibrator—see page 232.

Atwater-Kent Ford Ignition System.

On page 248 a detailed description of the Atwater-Kent ignition system is given. The Ford Atwater-Kent system is similar in design to that described, and **is furnished complete with cam gear cover plate which makes** a neat and secure fitting when the old commutator is removed (**figs. 1 and 2, page 810**). The distributor is accessibly arranged in a vertical position.

†**When fitting this system,** the old coil box on the dash is removed and a single unit non-vibrating coil, contained in a small box, is mounted on the dash. The radiator should be removed, to facilitate the placing of the cam gear cover, also the fan assembly and the spark control rod. The timer and wires are then removed, but the hexagon nut is retained to hold the bevel gear of the new system.

With this system the magneto can be used entirely for lights—or entirely removed, thus reducing the drag due to the magnets.

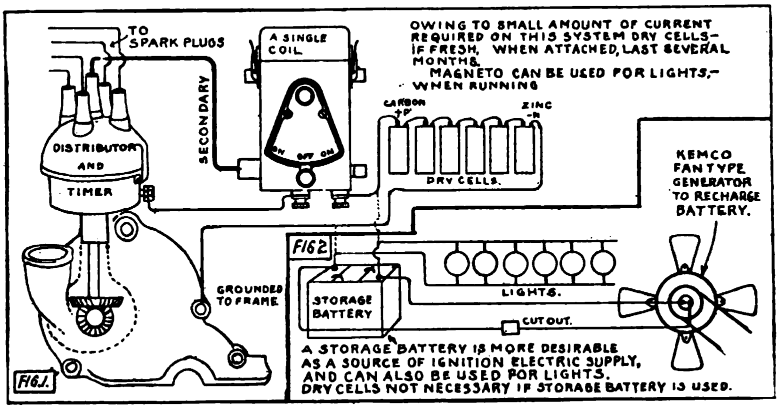
These single spark battery systems, and high tension ignition magnetos are especially adapted to racing Fords and speedsters. The more accurately timed single-spark, which these systems give, is especially valuable at high engine speeds and gives more power.

CHART NO. 355—Miscellaneous Electric Systems. Dressing Vibrator Points. A Battery Charger.

*See also pages 264, 232, 230. †When fitting an Atwater-Kent system to a Ford the piston is placed ¼ in. down after top, see page 316. **See also, page 234. Ford genuine vibrators are made of spring steel, heat treated and grain running one way; thus increasing resiliency. The points are high grade tungsten.

Atwater Kent Ignition and Kemco Generator.

Figs. 1 and 2 show how a direct current generator, of which the Kemco fan-type generator is a good example, can be used to keep a storage battery fully charged. The storage battery then furnishes a reliable source of electric current for lighting and other purposes, even when the engine is stopped. A cut-out is provided in the circuit as shown in cut, to keep the battery current from flowing back through the generator, when the engine is not running. (The Atwater-Kent Co., Philadelphia, Pa.)


TO SPARK PLUGS
A SINGLE COIL
SECONDARY
DISTRIBUTOR AND TIMER
ON OFF ON
GROUNDED TO FRAME
FIG 1.
OWING TO SMALL AMOUNT OF CURRENT REQUIRED ON THIS SYSTEM DRY CELLS— IF FRESH, WHEN ATTACHED, LAST SEVERAL MONTHS.
MAGNETO CAN BE USED FOR LIGHTS,— WHEN RUNNING
CARBON +P
ZINC -N
DRY CELLS.
KEMCO FAN TYPE GENERATOR TO RECHARGE BATTERY.
FIG 2
STORAGE BATTERY
LIGHTS.
CUT OUT.
A STORAGE BATTERY IS MORE DESIRABLE AS A SOURCE OF IGNITION ELECTRIC SUPPLY, AND CAN ALSO BE USED FOR LIGHTS.
DRY CELLS NOT NECESSARY IF STORAGE BATTERY IS USED.

Figs. 1 and 2.—Atwater-Kent Ignition and Kemco Generator.

*The Kemco Electric System For The Ford.

Generator: Consists of a direct current generator (13 lbs), driven from crankshaft by a Whittle V belt. It is mounted in the fan and charges a 6 volt battery which supplies current for lights, ignition and the starting motor.

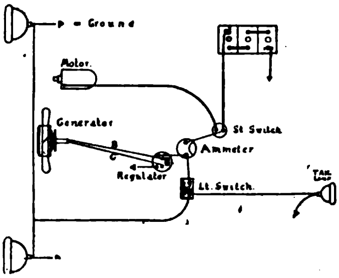
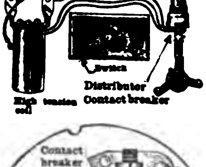


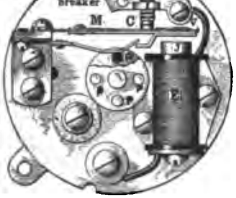
Fig. 106.—The Kemco wiring diagram.

The starting motor is geared back 16 times. It is a series wound motor and starts engine through a roller chain connecting with sprocket on an over-riding clutch connected to crank shaft.

New York "Vibrator-Les" Coil Ignition.

Consists of a non-vibrating coil, circuit-breaker etc., including all wires and parts ready to mount. The Ford magneto supplies current for this ignition as well as for lighting, etc.

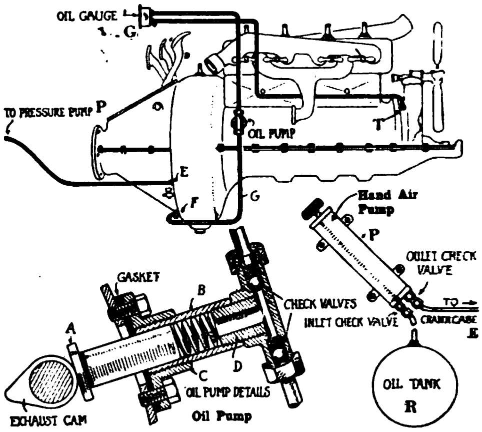




A feature of this system is the combination mechanical and electrical circuit-breaker. As is known, there are dead or neutral points when a Ford magneto generates no current (see page 265) therefore the function of the electro-magnet (E) shown in illustration, of the circuit breaker is to give a series of sparks in order that the dead points of magneto are fully taken care of. The mechanical finger M, by action of rotating pins (P) forcibly separates the contacts (C) at the completion of each sparking period. (New York Coil Co., 338 Pearl Street, New York.)

*Oiling a Ford For Speed.

Oil reservoir (R) placed at any convenient point from which oil is pumped by **hand oil pump** (P) to crank case (E). From here it is pumped by small piston oil pump to oil gage (G) on dash (thence to timing gears (T).



The oil pump is placed opposite No. 4 **exhaust** cam by drilling hole large enough to permit **head** (A) to pass through. Pump parts are made of brass tube (B) screwed to flange (C) having 4 holes for cap screws. Crank-case is tapped and leather gaskets inserted between. Piston of pump is made of steel. Bushing (D) is fitted into (B) to which remaining part of pump is **screwed.** Check valves and parts are shown.

Oil pipes are ¼ inch copper tubing using **solderless** connections. At (F) pet cock is removed and a fitting screwed into its place and tubing (G) leads from this to lower part of oil pump. A hole is drilled at (T) and tapped to take connection. (Motor Age.)

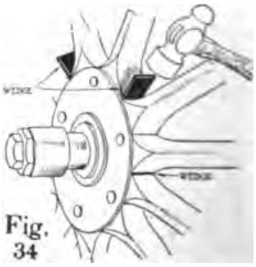


Fig. 34—Loose spokes in Ford wheels can be tightened by driving a piece of galvanized iron 2x1¼ in. forming a wedge. Looseness is due to drying out of spokes.

CHART NO. 356—Atwater-Kent Ignition. Kemco Electric System for Fords. Miscellaneous.

Other concerns who manufacture Ford electric starting and lighting systems are Westinghouse Electric Co., Pittsburg, Pa.; Gray and Davis, Boston, Mass.; C. F. Splitdorf, Newark, N. J.—see page 823. *See also pages 814 and 816 and page 864-A for Ford electric system for enclosed cars.

SPLITDORF MAG-DYNAMO.

Note—This motorcycle matter should have been with pages 843, 844 and Insert No. 3, but this being the only page in the book to spare it was placed here.

This is a combination of a magneto and a dynamo. The **dynamo armature** which generates ''direct'' current is placed above, (1) being the commutator. The magneto armature (U), is a regular armature with wire revolving, generating ''alternating'' high tension current, and is placed below. The two are entirely separate and independent.

The fields or magnets are not of the ''permanent'' type, but are of the ''electro'' type, excited in the first case by the current in the storage battery, or by the first few revolutions of the generator. The dynamo and magneto are separate and distinct otherwise, but combined in one unit.

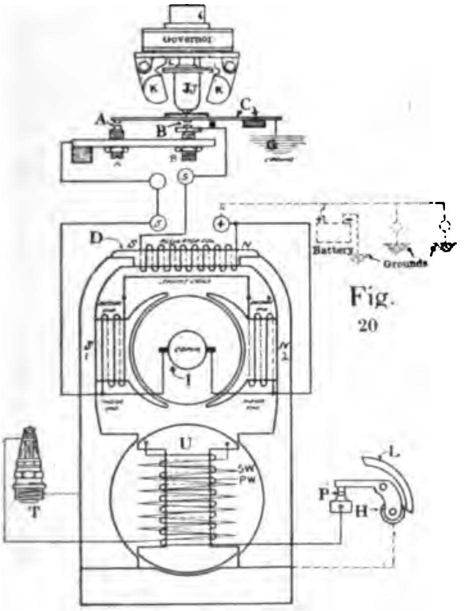


Fig. 20

Magneto Part.

The magneto part of the ''mag-dynamo'' supplies current for ignition. Its armature (U) is a double wound (SW-secondary—PW-primary) high tension revolving type. The interrupter parts are shown; P—platinum points of contact breaker; L—cam; H—roller grounded with frame or base; T—spark plug; P—points are set .015" and spark plugs .020" gap.

Dynamo Part.

The dynamo generates a ''direct'' current—which charges a storage battery, and also supplies current for lights. Armature is driven by a gear from the magneto or lower armature. With the battery ''floating-on-the-line'' (see page 334), the unit has a maximum output of 8 amperes at 7.5 volts at 1400 r. p. m. of engine, equal to 30 m. p. h. with average road gear.

Cut-Out Principle.

Principle of the automatic cut-out used with the dynamo is as follows:

When the rider gives the starter pedal (see page 844), a downward thrust as in starting, the mechanical governor part (J) is forced down by centrifugal action of arms (K), which acts upon the spring (O), bringing the main line contacts (A) together; this allows about 1 or 1½ amperes to flow through the field winding (and armature) magnetizing it so that the lower or ignition armature may produce sufficient current to spark the engine.

If the engine is stiff or hard to turn over the starting switch is depressed allowing four amperes to go through the shunt fields and armature, the starting switch merely cuts around the contacts (A) so that a strong magneto field is obtained when the rotation of the armature is slow. Of course when the battery is disabled, a powerful thrust on the starter pedal will rotate the generator armature fast enough to generate sufficient current to magnetize the field enough to furnish a spark at the plugs.

As the speed of the motorcycle increases up to about 30 m. p. h. the charging current also increases to about 8½ amperes, then through the increased action of the governor spring a second contact at (B) comes into action, this connects the regulator or bucking coil (D) into the circuit and magnetizes the soft iron core (N & S), which you will note, is magnetized the same way as the field coils, this action bucks the magnetic field of the generator armature and drives the magnetism down to the ignition armature field, weakening the generator field and strengthening the magneto field.

The ignition current is a straight high tension current from magneto at all times. When first starting the magneto field is energized from the battery and when running, from the generator. Otherwise that is all the connection the ignition or magneto has with the dynamo or generator.

Timing Magneto on ''Mag-Dynamo.''

Indian, Thor, Merkel, the piston is placed 5/16" from top of compression stroke with breaker box advanced. On the **Harley-Davidson** (Dixie magneto), 9/32"; **Excelsior,** 13/32"; **Pope,** ½"; **Dayton,** ⅜''.

A handle bar switch is also provided which should only be used when engine is cold and hard to start. When switch is depressed (with battery on circuit) it permits battery current to flow through the shunt fields (and armature), and provides a powerful magnetic field; in consequence, a hot spark is produced at low engine speed. Excessive use of switch will exhaust battery.

Adjustments of Mag-Dynamo.

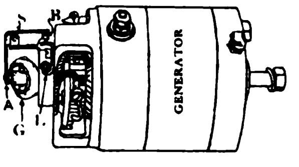
To adjust cut-out and current control; with engine idle and all lights turned off, remove regulator box cover and adjust the current control contact screw (A); the correct setting of the contact points should be between .015 and .025 inch. This setting will permit battery to discharge about 1 to 2 amperes. On the other side of the regulator box the setting of the main cut-out contacts can be made as follows: With engine running slowly loosen lock nut and turn current control screw (B) several turns to the left, increase the speed of engine until ammeter shows 8 ampere charge. With engine running at this speed (approximately 1200 r. p. m.), turn screw (B) to the right until ammeter needle drops back approximately 2 ampere charge, then set lock nut.

The fuse used in the circuit is a 15 ampere fuse. **Positive pole of battery** is connected to fuse block and negative terminal is grounded.

In case of failure of battery, three dry cells can be utilized, connected in series with carbon pole to fuse block and zinc grounded.

Splitdorf DU-1 Generator.

The principle of the mechanical cut-out on the DU-1 Splitdorf motorcycle lighting and battery charging dynamo is shown in this illustration. Note the centrifugal action of G, on armature shaft, causes a sleeve at higher speeds, to press against arm (A), which through hinge (S) makes contact at (B). It is similar to the ''mag-dynamo.''



On the late model motorcycles, the Dixie magneto (Insert No. 3) is used, and a separate and distinct dynamo is mounted separate. This dynamo is termed the ''DU-1'' dynamo as above.

CHART NO. 857—Splitdorf ''Mag-Dynamo'' for Motorcycles. Used on former models of Indian a
others, as shown above under timing. See page 843 for Remy and Insert No. 3 for Dixie Motorcycle M
neto and Indian Motorcycle Engine.

**Electric Lighting.

‡The bulbs supplied on present Ford cars for the electric head lamps are 9 volts, 2 amperes, and best results will be obtained by securing lamps of this voltage and amperage when replacement is necessary. (see fig. 87A, page 803, see also page 484.)

If a lamp burns out it will be necessary to replace it by removing lamp door.

Should the door be removed care should be exercised not to touch the silver-plated reflector or the bulb with anything but a soft, clean rag, preferably flannel.

To focus the lamps turn the adjusting screw in the back of lamp in either direction until the desired focus is attained. (see page 438.)

21 or 27 c. p. is standard for headlights. For side lamps, 4 c. p.; for dash or tail lamps, 2 c. p. (see page 434.)

‡The model T Fords are fitted with 18-volt magneto, and therefore a 9-volt lamp in series would really last longer than 8 volt lamps in series, but light would not be quite so bright. The older models magnetos gave 12 to 16 volts, therefore 6 to 8 volt lamps were used—connected in series.

Nitrogen bulbs type C, are best (see pages 432, 434), but are more expensive.

When lamps are connected in parallel, 12 to 16 volt, one ampere, 15 candle power type B bulbs can be used.

Proper voltage: You should get good lights at eight miles per hour and the bulbs should come up to full candle-power at about twelve miles per hour.

If the bulbs do not come to full candle-power, and cast a yellowish light, you should use a bulb of smaller voltage.

If the bulbs burn too brightly, throwing an exceedingly white light at slow speeds, the bulbs are too low voltage and higher voltage should be used. In this case, the life of the bulb would be very short.

Wiring.

Wire—No. 16 flexible lamp cord, run through metal tubing or flexible loom (see page 426), is usually used for wiring.

*Lighting Connections.

Fig. 1 is a "series" circuit and is the way Ford headlights are connected up as sent out from the factory. (see fig. 87A, page 803). The new model Fords are fitted with an 18-volt magneto and therefore two 9-volt lamps in series should be used. The older Fords magnetos give 12 to 16 volts, so that 6 to 8 volt bulbs should be used.

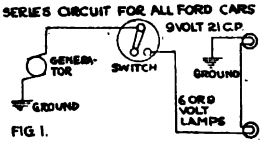

SERIES CIRCUIT FOR ALL FORD CARS

FIG 1.

Fig. 2 shows a "multiple" circuit, in which the lamps are connected in parallel and there is a ground wire for each lamp. When this type of wiring is used, 12 to 16 volt bulbs should be used on old Fords, and 18 volt bulbs used with the new type magneto. Careful running of the engine, to avoid burning out the bulbs, will be necessary when the headlights are connected in this way.

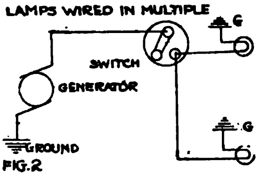

LAMPS WIRED IN MULTIPLE

FIG.2

Fig. 3 shows a "series-multiple" circuit. The headlights are wired in series. A pair of smaller bulbs for dash and tail lamps are connected together in series and wired to the same switch. It is important that bulbs connected in series be of the same amperage, as otherwise one bulb will be liable to burn out.

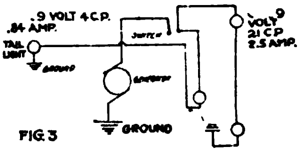


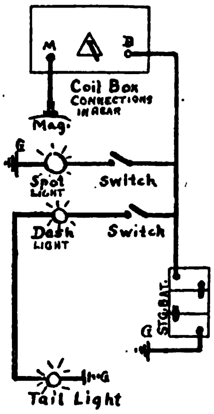
FIG 3

For dash and tail lamps, two or four candle power bulbs of 6 to 9 volts can be used according to model of car.

Storage Battery Connections.

For ignition, horn, and lighting—one terminal of the storage battery can be connected to terminal (B), rear of coil box, see fig. 87, page 803. The other terminal is grounded to frame of car or engine (make clean contact and draw tight with a bolt).

The wire to (B) connection on coil, should have 3 branches. One branch should connect, through a single pole switch, to a three-volt lamp on the dash. Then the wire from this dash lamp should proceed to a three-volt tail-lamp at the rear of the car. The remaining wire from the tail-lamp should be connected to the metal of the chassis frame. This places the dash and tail-lamp in series, so that if the tail-lamp should burn out or become disconnected, the dash lamp would also be extinguished, thus warning the driver. See foot note bottom of page 847, Packard Supplement.



Another wire should be connected, through a single pole switch to the spot light, the remaining wire from the spot light being grounded.

The third branch wire from the battery should be connected to the binding post on the left-hand corner of the coil box, looking from the radiator towards the dash. When the switch on the coil box is turned towards the binding post, to which the battery wire is connected; the battery will be connected for easy starting, and no other switch need be used.

The bulb for the spot light should be rated at six volts. The bulbs for the dash and tail-lights should be each rated at three volts. If desired, the bulb for the dash may be rated at two volts, and the bulb for the tail light at four volts. But they must be of the same amperage. Only two switches will be needed.

The usual voltage of storage batteries is 6 volts, therefore lamps of this voltage should be used.

The number of hours a battery will operate, depends upon the number and size lamps used and the ampere hour capacity of battery (see pages 433 and 441.)

When battery is exhausted it must be taken to a charging station and re-charged. There is a device known as the Warner battery charger, which it is claimed will rectify the magneto current from alternating to direct and battery can be charged from magneto. (see page 809.)

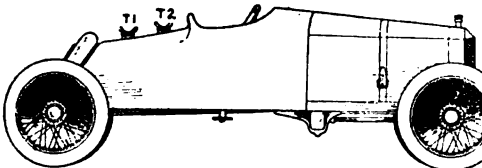
CHART NO. 358—Electric Lighting and Connections.

*See also page 430. ‡The voltage of the Ford magneto varies from 16 to 20 volts at average speed, see page 770. For headlamps, use two 9-volt bulbs in series—see page 434. If one wishes the brightest light possible to obtain, use two type C bulbs (page 434), which are gas filled and give 27 c. p. The gas filled lamp will not last as long as the type B, but gives a brighter light. If type B lamps are used, use two 9-volt, 16 c. p.; both consume 2 amp. Order for D. C. base.

See page 864-A for electric system of Ford enclosed cars.

*Speeding Up a Ford.

As I have helped in rebuilding several Fords that turned out exceptionally fast for the money invested in the job, I believe that I have gained some experience that may be of value to others, so will set down what I have learned, and it may be taken for what it is worth.



The author's model of a Ford car that has been made fast

There have been a few jobs turned out that ran into the thousands, you might say, and that were Fords in name only when finished. Of these I will have little to say, taking it for granted that what is wanted is something that is within the ordinary man's reach, both in a pecuniary way and, if he delights in doing his own work, in a mechanical way.

Division of Work.

The work naturally divides itself into two parts, the engine and chassis, or running gear. I will discuss the engine first, it being the most important part.

Engine.

The engine, as it comes from the factory, has bored cylinders, and as it is impossible, especially in a commercial way, to bore a perfectly true cylinder, the first thing you should do is to have your cylinders **reground** by a competent machinist, one who makes a specialty of this sort of work. Then you have a set of cylinders that are in line, have equal bore all the way through and are as near round as it is possible to make them.

The pistons I have used were cast of aluminum alloy, of course, and were equipped with non-leaking rings. Whatever make is purchased or if you have them made to order, see to the following things: There should be a rib or "reinforced run" from the piston-pin boss up to the piston head on the inside. Also several ribs should be cast across the inside of head. This both stiffens the piston and helps in carrying away the heat from the explosions. If you have the pistons made to order, it is advisable to have them cast and machined for two rings rather than three. This cuts down ring friction, lightens the part, and will hold compression as well as three or more rings if properly fitted.

****In fitting the piston, plenty clearance must be given**—from .007 to .008 at the top being about right. This may seem excessive, but remember that the expansion of aluminum is much greater than of cast iron.

This large clearance may lead to oil pumping and foul plugs, and so I have always turned and drilled an oil groove in each piston just below the lower ring groove as shown in fig. 2. The grooves are about $\frac{1}{16}$ deep and $\frac{3}{16}$ wide, having the lower corner rounded off. There are eight ⅛-inch holes drilled through the groove at equal distances around the piston, slanting down toward the inside. The top corner of the ring should also be slightly rounded. As the piston goes up the rounded edge of the ring and the groove tend to slide over the film of oil on the cylinder wall, while in going down the sharp lower edge of the ring scrapes the oil in the grooves and it runs through the holes to inside of piston, and thus back to crank case.

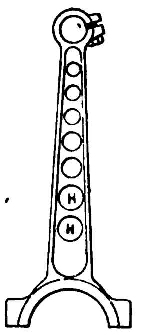


Fig. 1—The connecting rod has been lightened by dressing with file and drilling holes through inside web

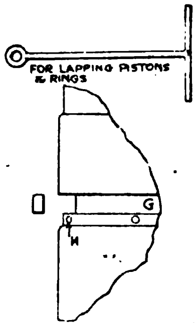


Fig. 2—The tool at the top can be used for lapping the pistons and rings. At the bottom is illustrated the preparation of piston and ring to prevent oil going into cylinder

Lapping Rings to Fit.

The rings should be of some good non-leaking type, or at least be step cut (see page 655.) Fit them in the cylinder with a gap of about .004, then lap them to a fit. In lapping them in, they should be placed on an old piston, cast iron is best, and worked back and forth in the cylinder, keeping the cylinder walls well covered with a mixture of exceedingly fine carborundum or some other abrasive and oil. (see page 650.) As the piston is moved back and forth, also give it a slight rotating movement. I have used a tool similar to the one shown in fig. 2 for this purpose. The wrist pin goes through the hole shown.

Job Repays Trouble.

This is a long tedious job, but you will be well repaid if it is properly done. It takes from 1500 to 2000 miles to wear in a set of rings under running conditions. Be sure and get all the abrasive from the cylinder walls and rings after the lapping is finished, or it will continue after engine is running.

You can lighten the connecting rods considerable by dressing them up with a file and drilling several holes through the inside web. This does not dangerously weaken them, judging from my experience. Do not drill any holes in the last inch toward the bottom, as this is where the most strain comes, and anyway this part of the rod is more of a rotating than a reciprocating mass. In one car the rods were chucked up and the lower ends turned out and bearings (made of Kelly metal) were cast, turned to fit and installed. After 2500 miles of driving, most of it at

CHART NO: 359—Speeding Up a Ford.

(By E. B. Williams in Motor Age.)

---

*See also pages 760 and 761 for additional matter. **See pages 645 and 651.

—continued from chart 859.

high speed, the engine was torn down and these bearings showed practically no wear. **This metal, if used, must be fitted with plenty of clearance.**

Large Valves are Better.

You will secure better results if the valve ports and pockets are turned out and larger valves used. No trouble is liable to be encountered in boring the seats and ports from the top, but when going in from the side the tool will sometimes break through, and you will have to have the hole welded. It is best to do this before regrinding the block, as the heat, if welding is necessary, will warp the walls surrounding the weld. The ports can be enlarged $\frac{1}{16}$ inch and this is necessary if you expect good results. I have used tungsten steel valves, giving the stems plenty of clearance.

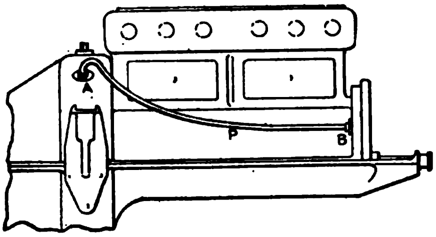


Fig. 4—One auxiliary oil system

The springs must be stiffened considerably, either by installing heavier springs, or by placing spacers between the upper ends of springs and the cylinder casting.

It is good practice to install adjusters, using the kind that screws into the valve push rod, it being necessary to anneal, drill and tap the rod. While you are about it, drill the length of rod to the head, but not through. This lightens the part and cuts down inertia, thus helping the valve to close quicker.

Cam Shaft.

At this stage we come to the camshaft, which should be of the high-speed type if you can afford it, several different makes being on the market.* I have secured good results with shafts taken from Ford cars of 1912 or earlier vintage. You will find them considerably different from the new type. If the regular shafts are used do not try changing the timing, as one tooth on the coarse pitched timing gears of the Ford throws the timing out too much.

Remove Magnets.

Leave out the magneto armature coil assembly, and remove the magnets from the flywheel, screwing back the brass screws and brass magnet supports only. It will be necessary to shorten the screws a little. They will kick up almost as much oil as the magnets, and considerable drag will be removed.

*Crankshaft.

Now see that the crank shaft is perfectly true, then assemble the crankshaft and gearset and try out in the lathe, first seeing that the bushing in the driving-plate assembly is a good fit on the gearset shaft. If there is any wobble it will probably mean turning up both sides of the gearset-shaft flange and the back side of the crankshaft flange. Now reassemble and turn up the flywheel if necessary to make it run true. Take out the assembly and try on two perfectly level knife-edge testing bars for balance. If one side of flywheel turns down, take out material on that side until the wheel stays where you turn it. This may seem a lot of trouble, but it is essential that these parts be true and in perfect balance.

Gearset May Affect Bearings.

The power and added strain at high engine speeds will sometimes cause the gearset to whip out the babbitt bearing at the rear in what is called the front ball cap. This will in turn loosen up the rear main bearing. I have found it advisable to turn out the ball cap and equip it with a bronze bushing, fitting it rather loose on the gearset driving-plate assembly shaft to give lots of room for oil.

**Lubrication.

It is good practice to fit some auxiliary oiling system besides the gravity one with which the Ford is equipped. If money is no object a force feed system can be installed, which should have leads running to all four cylinders, being tapped through the walls on each side near the bottom of the cylinders and also a large lead running to the front of the crankcase. I have secured good results by cutting a $\frac{7}{8}$ hole near the top of the gearset case on the right side and running a piece of brass or steel tubing, also $\frac{7}{8}$, to empty into the timing-gear case as per fig. 4. The front end need be only a snug fit in the case, but the rear end must have a flange which can be bolted to the gearset cover, using a gasket between. A sheet-iron partition can be installed just back of No. 4 cylinder. This can be made as high as it is desired to carry the oil level under the connecting rods. Of course every car intended for long distance should also have a hand oil pump convenient to the driver which will force oil from the reserve oil tank to the front of the engine.

High-Tension Magneto Not Used.

While I believe a good high-tension magneto to be the best ignition on earth, I have discarded it in Ford work on account of the additional power needed for driving. Turning a magneto armature over at two or three thousand revolutions a minute requires more power than is generally thought, in my estimation. I have used a battery distributor system because it is light, is easily driven and works on the open circuit idea, thus requiring only four or five dry cells for current.

Cooling

Some additional cooling is needed. I have found the large V honeycomb type of radiator to be best. You will find that it will probably be unnecessary to use a fan with one

—continued in chart 861.

HART NO. 360—Speeding Up a Ford—Continued.

See also page 819. "Special racing camshafts." **See also pages 816, 810.

Counterbalances which can be clamped to a Ford crank shaft and which the makers claim will increase the flex[illegible]ility and power of the engine are manufactured by The Dunn Counterbalance Co., Clarinda, Iowa.

of these. If you are building a streamline body it will be better to have some radiator maker build one of the tall narrow kind, (see page 190 and also chart 366) to order, or you may purchase a stock radiator. If it is necessary to use the original radiator, have a good tinsmith build on an extra tank to the top, either back under the hood, or point it and extend it out in front. Anyway, the original equipment must be improved upon for fast work.

Carburetion.

For a carburetor I recommend a 1¼- inch type, with a 1¼-inch built-up steel-tubing manifold. The one illustrated in fig. 5 has given good results. No cast manifold is efficient, as the rough surface inside with possible fins and irregular turns, seriously hampers the flow of gas.

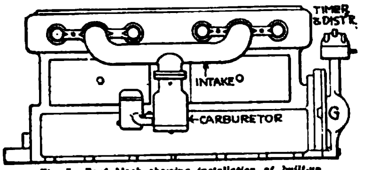


Fig. 5—Ford block, showing installation of built-up manifold, carburetor and ignition apparatus

Air Pressure.

It will be necessary to use air pressure on your gas supply as the carburetor should be set high, thus shortening the manifold.

Inlet and Exhaust Manifold.

Each end of intake manifold has a collar brazed or welded about $\frac{5}{16}$ inch from the end; also the exhaust pipes, which are of steel tubing and run straight out through the hood. A copper-asbestos gasket is slipped over the end of manifold and makes a tight fit between the collar and the cylinder casting. Manifolds are held on by crows' feet, which slip over the original studs and bear against the outside of the collars.

Running Gear.

When we come to the running gear we have two things to consider. If the car is to be used for fast track work only, by all means lower it. But if you want it for other work too, you will probably have to leave it up in the air, and sacrifice some efficiency.

The best way to lower the front end, to my notion, is to have a new axle made similar to the one illustrated below in fig. 8. It leaves your frame strong and rigid, and an added advantage is that your radius rods are still in a straight line.

The rear end of the frame can be lowered by cutting off the side members just in front of the rear cross member and using steel forgings as shown in fig. 3. The front end if a cheaper construction is desired, may be lowered as shown in fig. 8, by riveting pieces of channel iron on the sides of the frame, letting them stick out in front about 5 inches. An extra cross member, similar to the regular Ford front cross member but with a high instead of a low center, is riveted across the front to the two, new side extensions. This sets your front axle ahead enough to clear the radiator, and the amount of frame drop depends on the shape of your new cross members (as can readily be seen), which carries the spring. With this method it will be necessary to lengthen out your radius rods and the starting crank.

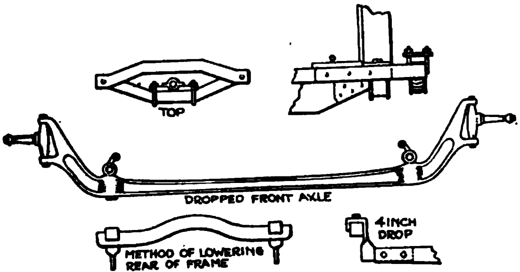


Fig. 8—Top—Method of lowering front end of frame by lengthening frame out and installing extra front cross member. Center—Dropped front axle. Bottom—Method of lowering rear end of frame 4 in.

Assembly Should Be Kept Rigid.

In tilting the steering post it is desirable to keep the assembly as rigid as possible. Have it bolted to the dash securely, blocking behind the dash plate with a wedge-shaped piece of hardwood shaped to fit the space caused by lowering. It will be necessary to drill a new hole in side of frame for bolting down the bracket. You can block under the bracket where it tips from the frame with steel washers before bolting.

Steering.

The steering-gear connecting rod and the spindle-arm connecting rod should both be stiffened. An easy way to do this is to place a piece of small channel iron or steel tubing alongside the rod and bind the two together with several layers of tape, taping the whole length of rods, and then shellacing the whole job. This is cheap, easy to do, and makes a permanent job.

Axle.

See that the axle tips toward the back of the car at the top. The nearer vertical the axle is set, the harder it is to steer, and when the top of the axle gets ahead of the bottom, it is almost impossible to keep the car in the road.

A good gear ratio for a car put up like this one is about 2½ to 1. While I have always made my own special gears, several concerns are making and advertising them. Some makes sell for $15.

While you have the rear end down see that the differential gears are a good fit on the inside ends of the axles. These sometimes get loose and tear the key seats out of the axle.

The rear hub brakes on the Ford were only intended for holding the car when standing still, and if used when running they do not last long, and are not very efficient at that. The best brakes I have used so far were secured from Los Angeles, Cal., costing $16 per set. They have large drums and external contracting bands lined with raybestos.

Be sure and see that the transmission bands are a perfect fit on the drums and are not adjusted too tight. They can set up quite a drag if not properly set.

Speed Thus Obtained.

I had one of these cars do 68 m. p. h., and another one equipped with wire wheels 71. Of course, if economy is no object a new cylinder head with overhead valves and camshaft, wire wheels, etc., can be added, the stroke lengthened and in this way a few miles per hour gained, but for the man of moderate means the foregoing described car will go fast enough and furnish lots of pleasure in the building.

Cost.

The job I have described will run from $200 to $350, depending on how much of the work the builder is able to do himself.

I have not taken up the construction of the body, as that depends upon the taste or ability of the man who is building the car, also upon the use to which it is to be put. For racing a pair of bucket seats and a gas and oil tank bolted to the frame will get by very well. but are not comfortable or very clean. The body shown on page 818 is good, being neat in appearance, can be made comfortable, and offers little resistance to the wind. While it is not drawn to scale, the proportions are near enough right to give the idea. There is a gas and oil tank in the rear compartment, with the spare being slung on the extreme rear. This body should cost you about $150 at the average body builders.

Don't forget your hood straps, and have them very substantial.

CHART NO 361—Speeding Up a Ford—Continued.

Lowering the Frame.

The most important point in converting a Ford into a speedster is the lowering of the frame, because this car presents an awkward appearance with bucket seats and big gasoline tank when high off the ground.

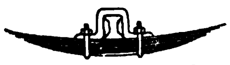


Fig. 1—One of the simple methods used to undersling Ford front springs

If semi-elliptic front springs are used, instead of the regular transverse spring, the semi-elliptic springs can be fastened under the axle by means of a U-shaped piece of flat steel, per fig. 1. Thus, the front of the car can be lowered several inches with but little change in the front axle itself. However, the frame will have to be changed, or special spring hangers fastened to the frame to form supports for the front ends of these semi-elliptic springs.

Fig. 3 shows how a special dropped front axle can be made to lower the front end of the car without making necessary inconvenient changes in the chassis frame.

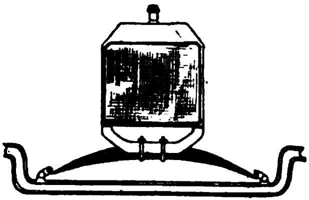


Fig. 3—This Ford front axle is a special forging with dropped ends

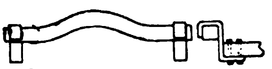


Fig. 4—Method of lowering rear spring 4 inches. The end of the panel was cut off and a gooseneck fitted as shown

Fig. 3, chart 361, shows how 4 inches can be cut from the rear end of the frame on each side and the regular Ford cross member of the chassis frame supported on two goose necks made from flat, bar steel. This also will give a frame about 4 inches lower than the stock car.

Fig. 2 shows how the rear of the frame can be lowered by using the brake arm studs in the rear axle housing to fasten a forked steel bar from the axle to the frame. About two inches forward from the fork the spring shackles are bolted and the regular cross spring suspended from them. This gives about a 4 inch drop. (Motor Age.)

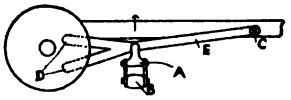
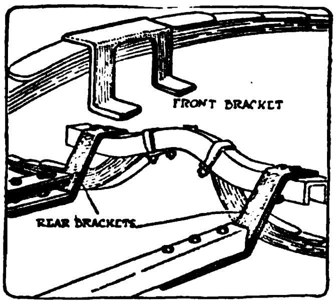


Fig. 2—Underslung rear spring. Forked rod E was anchored at the brake rods D and at the frame at C. Spring B was shackled to the rod by A

Another Method of Lowering Frame.

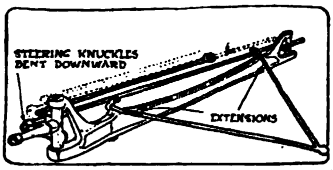
The work can be done by any good blacksmith and will not cost more than $15. The principal changes in dropping the frame are in making front and rear brackets which allow the frame to be hung 6 inches lower, as shown below.



The front bracket, consists of a piece of iron bent as shown, and made out of ½ by 2-inch stock. The method of attaching this is clearly indicated. The top is clamped over the spring, and the bottom ends are bolted to the cross frame member.

The form of the rear bracket is also shown, and its attachment is even simpler than the front. The frame is sawed off and the two brackets are bolted in place. Care should be taken in making the change not to alter the position of the axle relative to the frame backwards or forwards.

The attachment of the front bracket requires that the axle be pushed forward a certain amount —probably 3 inches. This must be compensated for by welding pieces in the radius rods running to the front axle.



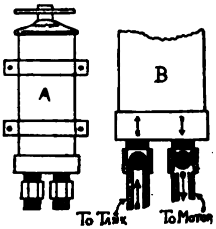
Cut courtesy Motor Print.

The Sketches Show How the Ford Frame May be Lowered.

The lower position of the crank-case requires that the steering knuckles be bent downward so that the tie rod will clear it. (Newsabout Fords.)

*Auxiliary Oiling.

The present oil system in the Ford engine, while suitable for all ordinary purposes, is inadequate for high speed. The oil rotating with the fly-wheel is caught in a small funnel and carried through a ⅜-inch tubing to the timing-gears flowing to the engine case where it lubricates the moving parts of the engine. This funnel can hold only a certain amount of oil and at any speed the tube can handle only a ⅜-inch stream.



Home Made Oil Pump

The funnel should be made larger, the long way, and higher to increase the weight there, and the tube replaced with one 7/16 inch in diameter.

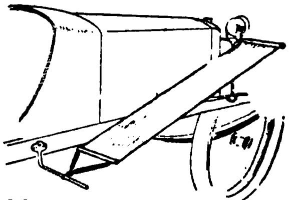
An auxiliary pump is frequently connected to engine as shown just above. An old tire pump can be converted into a pump as follows:

An old tire pump is cut off about six inches below the handle. A metal handle substituted for the wooden one as shown in the drawing. The bottom of the pump is removed and carefully soldered and the air outlet soldered up. Two check valves, requiring no solder, are fitted to the bottom of the pump by drilling and tapping. The valves are, of course, inserted so that they will act in opposite directions. The valve allowing oil to enter the engine allows the oil to be forced out of the pump, but will not allow it to re-enter. The other valve, working in the opposite direction, permits oil to come from the supply tank to the pump when the handle is pulled up. When the handle is pushed down one valve closes while the other, (the one permitting oil to enter the crankcase), opens.

The supply tank may be located where most convenient and is connected to the pump by copper tubing. The pump is placed under the front seat in a position where it can be operated easily.

Fenders.

For fenders we would suggest canvas guards, front and rear. They are easy to make and noiseless. Put a couple of coiled springs at the lower ends, and they will never sag. (Newsabout Fords.)



A Canvas Mudguard, Noiseless and Easily Made – Mudguard Support Also Makes Good Lamp Bracket

CHART NO. 362—Lowering Frame for Racing—Miscellaneous Speed Pointers.

Note: This matter is collected from various authoritative sources. Writer has not personally tried out any of the devices. *See also pages 810 and 814.

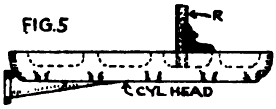
Cylinders.

If the car has been driven over two or three years, it will be probably advisable to have the cylinders rebored to the Ford standard of 1/32 inch oversize. While this will only add about one-half horsepower to the engine on account of the larger bore, the fact that the cylinder casting will have aged sufficiently to attain its permanent set, will have more influence on the power of the engine than is often supposed.

*Compression.

It is, perhaps, not generally known that the cylinder heads on the Ford cars have not always been the same. The cylinder heads used a few years ago were not as deep as those used on the latest models. †To obtain higher compression (which is necessary for high speed work), it will be well to secure one of these old style cylinder heads. They can be identified by comparing them with cylinders of the latest type, using a depth gauge as per fig. 5.

FIG.5



Depth of cylinder head

These high compression cylinder heads give more power, but they are harder on the bearings and make the engine more liable to knock, so that many owners are very glad to trade them for cylinder heads of the latest type, if the difference is pointed out to them.

It is true that different compressions affect the power of explosions and that an uneven compression ratio in different cylinders will, consequently, cause an engine to jerk. If the compression is excessively high it can keep the spark from jumping the gap in the plug.

If the old style cylinder head cannot be obtained, it is possible to plane off about one-eighth inch from the bottom of the cylinder head and thus increase the compression of the engine to about 70 pounds to the square inch. The work must be carefully done, so that a true surface is obtained, or water leaks and loss of compression will result. Good gaskets should be used between the cylinder head and the cylinder blocks, so that no compression will escape. By the use of Prussian blue and a scraper, it is possible to fit the cylinder head to the cylinder block without the use of a gasket, thus reducing the compression space about 1/32 of an inch.

Unless the compression is the same, the engine will not be in good balance and loss of power will result. The power lost when one cylinder does not fire is far more than ¼th, and this is due largely to a loss of balance.

Valve Springs.

One of the most important features necessary to obtain increased power is good valve action. Valve springs are cheap, and it pays to install a new set of valve springs occasionally, even if the old ones do not seem to be worn out. Lively springs close the valves promptly and this is especially necessary if the engine is to be run at high speeds. If it is to be used for racing and the last ounce of power is desired, it may be advisable to use special valve springs that are stronger than the regular type but which are more apt to break the valves and are more noisy.

It is, of course, understood that the engine will be kept free of carbon and the valves ground frequently, if used for speed work.

**Valves and Cam Shaft.

In order to obtain the highest possible speed, it is necessary that the valves be timed differently than is standard practice. For racing, it is necessary that the valves be given a greater lift, that is, open farther, and that the cams be so designed that the valves be opened and closed more quickly. Now these quick-action valve cams cause greater wear and tear and make more noise. It is also true that the engine will not run smoothly on high gear at speeds of less than 20 miles an hour, so these special cam shafts are only of value when the car is used for racing only. **For use as a speedster**, on average roads, the regular camshaft is probably the best. It is easy to set the timing gears one tooth ahead and so open the valves earlier, but this also means that they close earlier and so little is gained by this practice.

It is sometimes asserted that the speed of the Ford engine is purposely limited by the small size of the ports or valve openings. This is probably done so that careless drivers will not run the engine too fast, but if it is intelligently handled, it is true that greater power can be obtained by enlarging the ports or valve seats. A wide seating for the valves is not necessary and tends to restrict the flow of the gases. One thirty-second of an inch is wide enough, but requires more frequent grinding and valve adjustment than a wider seating, as it wears more quickly under the hammering action of the valves. Fig. 2, (page 818) shows how the valve ports may be bored out larger, but great care should be taken not to break through the sides of the water jackets, as the walls are not always uniform thickness, due to the displacement of the cores when the castings are made.

Getting a large charge of fresh gas in the cylinders for each explosion is one of the essentials of maximum power. Along these same lines is the necessity of getting the old burned gases out quickly. For this reason, a muffler is often omitted from racing cars, although a car cannot lawfully be operated without a muffler on the roads of many states. However, a cutout is easily attached, and if used in moderation, serves the purpose very well. If no muffler is used, the end of the long exhaust pipe should be somewhat flattened, so that the sound waves will be somewhat broken up as they emerge. A number of small holes, and diagonal saw cuts will also aid in giving a free exhaust without undue noise Or, it is possible to remove one of the baffle tubes from the muffler, or bore addi-

—continued on next page.

CHART NO. 368—Increasing the Speed of a Ford—by Murray Fahnestock in Fordowner.

---

*In Ford races held in Chicago, there was not a car in which attempts had been made to increase compressio by reducing compression space, and cast iron pistons seemed to predominate. Gear ratios used were fro 2¾ to 3 to 1. For long races, radiators were fitted with tanks for extra water capacity.

**Sometimes the inlet valve is made to open slightly earlier for speed work. In this case engine will not id down very well. See also page 909 and pages 793, 629 and 640 on compression. †Clearance between pisto head of Ford high compression cylinder is about 1".

tional holes in the muffler tubes, so that a comparatively free exhaust is secured without losing the muffling qualities altogether.

Carburetion: To obtain the maximum speed from the engine, a larger carburetor, say the 1¼-inch size, can be used. This will not be economical of gasoline, and the engine will not run as smoothly at low speeds, but with a larger carburetor and a larger intake manifold, which should be smooth inside, the engine can draw in fuller charges at high speed.

The piston rings certainly create friction as they rub against the cylinder walls, and if the top ring is so well fitted that no compression will escape past it, the two lower rings are unnecesary, as they cannot stop any gases that do not reach them. Some owners prefer to fit special piston rings, see page 655, at the top of each piston and claim that it makes the engine run more freely. However, if only one ring is used, greater care must be taken to keep that one ring in good condition.

If the rings are fitted on an old piston, they may be lapped in by using emery and a more perfect fit obtained, and then they may be placed on the new pistons for actual use. If lapped on the new pistons the grooves (for the rings) in the pistons are apt to be worn.

Pistons: For high speed driving it is necessary that the pistons should be rather a loose fit in the cylinders, as otherwise they are apt to seize when the inevitable expansion due to heat occurs. This does not mean that it is not necessary to rebore cylinders or fit new pistons on old cars, for in such cases, the cylinders and pistons are apt to be worn oval, due to the thrust of the connecting rod and so do not have the proper clearance all around.

Light pistons are certainly an advantage, and the use of aluminum has much to recommend it, especially if new pistons are to be fitted in any case, as then the additional cost will not be so much. In case the cast iron pistons are used, they can be greatly lightened by careful drilling, care being taken not to weaken them too much. Most of the holes should be drilled near the ends of the piston pins, for if drilled on the sides, where the thrust occurs, they permit the oil to be squeezed out and spoil the lubrication where it is most needed.

Light reciprocating parts are the secret of high speed and power. If we consider structural iron work, we will notice that beams are made very heavy along the edges where the strain occurs and often the center is only a light lattice of thin steel strips. (see fig. 1, page 813, for a drilled rod.)

It is possible to balance the rotating masses of the engine, but it is not practicable to balance the reciprocating weights, except to a small extent. But by making the parts lighter, the unbalanced forces and power-absorbing vibrations are greatly reduced. It is more important to lighten the connecting rod at the piston end than at the crankshaft end, because the piston end of the connecting rod has a reciprocating motion while the big end bearing has a rotary motion.

Connecting rods: It is also important that the four connecting rods be of equal weight and that the four pistons have the same weight, so that they will tend to balance each other and reduce vibration.

The alignment of the connecting rod bearings is important. This can best be tested in special jigs which are part of the equipment of every branch of the Ford Motor Co. If one wishes to align these bearings, the piston pin can be placed in one end of the connecting rod, and a cylindrical pin, the size of the crank pin, placed in the other end of the connecting rod, and two steel squares used to make sure that the two bearings are in perfect alignment with each other. (fig. 1.) This only tests the alignment in one direction and to test them in the other plane, it will be necessary to use the same tools and a perfectly flat surface, so that the distances from the pins to the plane surface can be measured and made equal on each side. (see figs. 1 and 11, page 646.)

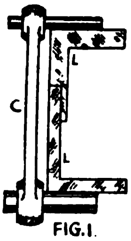


FIG. 1.
Alignment

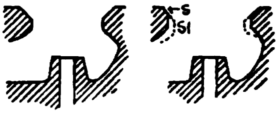


FIG. 2.
Increasing Port Opening

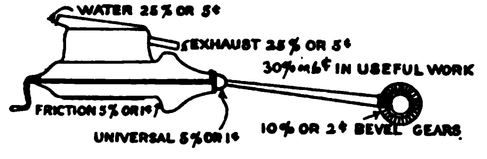
Crank shaft: It is important that the crankshaft be in good running balance, which is different from being in balance when at rest. It can be tested by revolving the crankshaft at different rates of speed, between centers. The bearings of the crankshaft are also important, and, after they have been scraped to a good fit, the engine should be driven by an outside source of power until the bearings fit perfectly.

Flywheel: It hardly pays to reduce the weight of the flywheel, especially if the power of the engine is increased and a higher compression used, but the flywheel alignment can be tested by holding a steel pointer near it when the engine is running. for a wobbly flywheel involves a loss of power.

Ignition: For ordinary road use, the Ford ignition system will furnish about all the sparks required, but to obtain the very highest speeds, the more accurately timed sparks of the high tension magneto are an advantage. If the Ford ignition system is used for high speed work, the magnets and magneto coil assemblies should be of the latest type and the vibrators should be adjusted more tightly, so that there will be less lag in the ignition. The spark can be advanced by bending the rod from the lower end of the steering column to the timer. It is also well to be sure that the timer is in good condition and that the spring holding the roller against the segments is strong and quick acting. It may be even an advantage to fasten an additional spring beside the one already in place.

Lubrication: Adequate lubrication plays an important part in the maintenance of high engine speeds. A good quality of thin oil, which does not burn easily, should be used. Heavy oils exert a constant drag, and are not needed, if the engine is in good mechanical order. Oil holes can be drilled in the connecting rod bearings and larger oil grooves cut in the bearings. It is also well to fit a much larger oil pipe and oil funnel. The oil pipe can be drilled with holes opposite each connecting rod, so as to supply a good oil bath.

HART NO. 864—Increasing the Speed of a Ford—continued.



WHERE THE MONEY GOES GASOLINE AT 20¢ A GALLON

Where the Money Spent for Fuel Goes—Diagram Shows Different Points Where Losses Are Greatest.

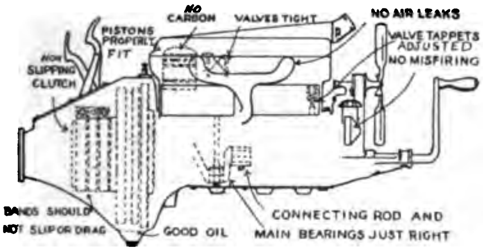
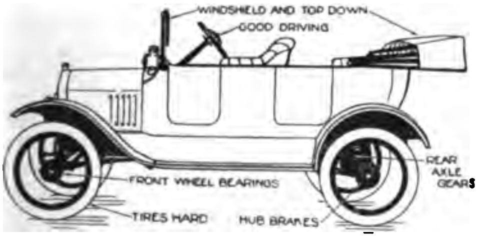


Diagram of Engine Emphasizing Parts Requiring Attention for Saving Fuel.

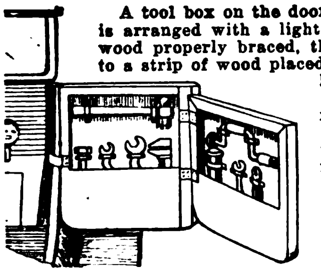


Points at Which Gasoline Can Be Saved On Complete Car.

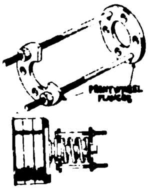
How To Save Gasoline.

The illustrations point out where care should be exercised in order to prevent loss of power by decreasing friction and waste. To gain power means a saving of gasoline. The illustrations show where if parts are kept in proper order, there will be a saving of power. Excess of power and loss of gasoline would come from poor driving, too much flooding carburetor, windshield constantly up, dragging brake bands, etc., see the three illustrations above. (see also page 802.) (Fordowner.)

**Miscellaneous Useful Devices.



A tool box on the door—The front door is arranged with a light door of strips of wood properly braced, the hinges screwed to a strip of wood placed up and down behind the metal door lock; the inner door spring catch fits nicely in the notch left by removing the center cross brace next the leather stop. Then a pocket made of canvas or leather in the lower portion of each door with a strap or two to keep the tools in place. Replace the door lining and put new strips of gimp, tacking with black headed tacks as it was before. (Motor World.)



This is a device for compressing the Ford clutch spring. The end plates are Ford front wheel flanges, one being cut away, so that it may be inserted over the shaft, behind the spring. Two bolts connect the plates and by tightening the nuts, the plates are drawn together, compressing the spring. With this device, only one pair of hands needed to remove the pin.

Motor speed per mile. The crank shaft of a Ford car makes, 2,446 revolutions in one mile, and when running at a rate of twenty-two miles per hour it turns over 897 times every minute.

Ford Magnet Remagnetizer.

FIG. 3

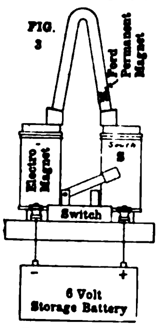
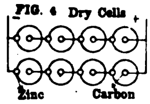


FIG. 4 Dry Cells



It is not necessary to remove the flywheel from engine when remagnetizing Ford magneto magnets with this device. Simply remove transmission case cover so that the ends of the magnets are available. Use a compass (see fig. 3, page 303) to determine North pole of each magnet and chalk them, also chalk the South pole of the remagnetizer. Place the S pole of remagnetizer so it will be on the N pole of the magnets. Turn the flywheel over after remagnetizing one magnet and remagnetize each magnet separately. After remagnetizing, check the polarity of all magnets with compass again. The connections are shown in fig. 3. The storage battery can be either a 6 or 12 volt battery. It is possible to use 6 or 8 dry cells if connected as per fig. 4.

Magnets of all types of magnetos can be charged with this remagnetizer. When remagnetizing magnets which are separated from the magneto, it is well to place a "keeper" across the magnets until placed on the magneto. It is also advisable to rap the magnet a few times with a piece of wood while being remagnetized. See advertisement, page 864-J.

***Larger Valves.

Valves if made larger will permit slightly more gas to enter and will increase compression and power, but heating will also be increased, therefore a circulating pump or larger radiator may be necessary. A valve lift of 5/16 inch with a valve seat 5/32 inch, measured across slanting face would be about right.

Valves are now 1 5/16 inch outlet and 1½ inch diameter across widest part, but for racing, valves 1⅓ inch diameter outlet and 1 11/16 inch across widest part would be better. The valve ports can be enlarged to this size by reaming and grinding. Tungsten valves of 1⅝ inch are sometimes used.

Circulating Pumps

Of unique and simple design are manufactured, by Giddings & Lewis, Fon du Lac, Wisconsin.

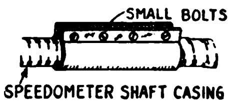
Muffler and Cut-Out.

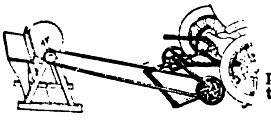
The construction of the Ford muffler and method of attaching one type of cut-out is shown on page 84. The outside diameter of exhaust pipe of a Ford is 1¾ inches, therefore a cut-out would be required which would fit over same. (see page 606.)

****Paints for Fords.

No. F113—Blue ground, first coat.
No. F115—Body blue color varnish.
No. F751—Body varnish, clear.
No. F104—Black fender, quick dry.

To repair a broken speedometer shaft casing a sleeve is used as shown in illustration. A layer of tape is applied first.





Power From Rear Wheels.

A device for this purpose is shown in illustration.

CHART NO. 365—How To Save Gasoline. Miscellaneous Useful Devices.

See pages 730 to 745. ***See pages 791, 609, 814. ****See page 509. **To repair a hole in a top—see page 847. ***Special racing camshafts, which will lift about 1/16" more than standard can be had of some of the Ford specialty houses.

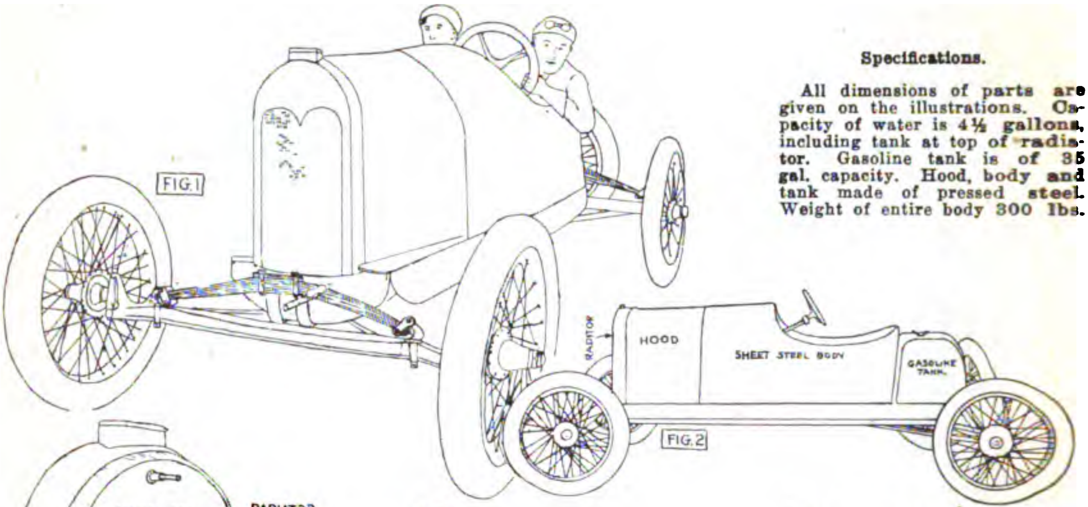


FIG. 1

FIG. 2

Specifications.

All dimensions of parts are given on the illustrations. Capacity of water is 4½ gallons, including tank at top of radiator. Gasoline tank is of 35 gal. capacity. Hood, body and tank made of pressed steel. Weight of entire body 300 lbs.

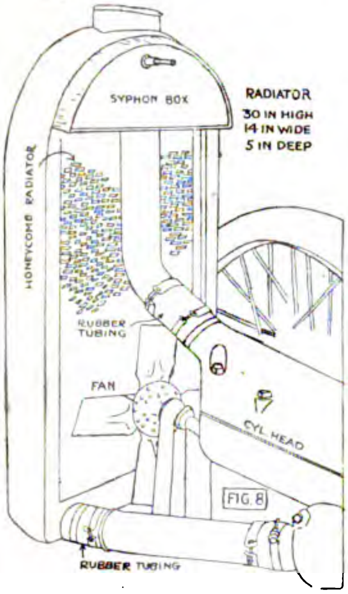


FIG. 8

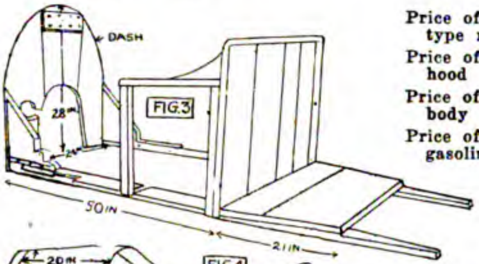


FIG. 3

Price of special racing type radiator	$50.00
Price of special racing hood	12.00
Price of special racing body	55.00
Price of special racing gasoline tank	8.00

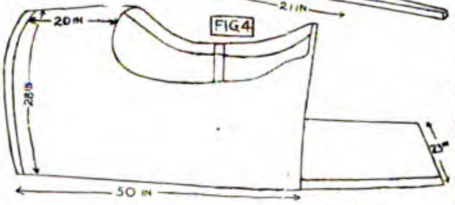


FIG. 4

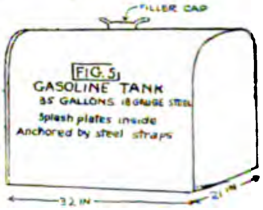


FIG. 5

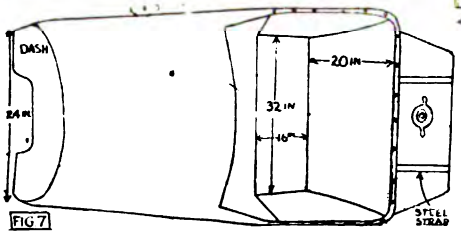


FIG. 7

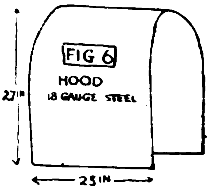
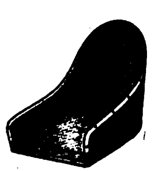


FIG. 6


RACING SEATS
For use on the speedster

Bucket type racing seats for the roadster, or speedster. The shell is heavy gauge steel, attached and braced to wooden seat bottoms, and upholstered with substantial imitation leather, known as mule skin. (Am. Auto Accessories Co., 621 Main St., Cincinnati, Ohio.)

Reducing Wind Resistance.

One way of increasing the speed of the Ford car is by reducing the wind resistance, by taking off the top, mudguards, and windshield. Also, by the use of special racing bodies, of which the body made by the Champion Racer Co., 1920 So. Wabash Ave., Chicago, Ill., is an example.

The radiator is designed especially for racing and is high and narrow, thus reducing the wind resistance and improving the appearance. The radiating surface is of the patented bridge fin type and the construction is of copper throughout.

***Miscellaneous Parts Manufacturers.**

Addresses of concerns who make a specialty of parts are as follows: Laurel Motors Corporation, Anderson, Ind.—cam shafts and valve in head cylinders (16 valves). Geo. L. Dyer, Champaign, Ill.—sixteen-valve cylinder head; Henry Pugh, St. Louis, Mo.—special work for converting Fords into racers. Ahlberg Bearing Co., Chicago, Ill.—ball bearing thrust washers for rear axles. Aluminum Mfg. Co., Des Moines, Ia.; McQuay-Norris, St. Louis; Butler Mfg. Co., Indianapolis, Ind.—aluminum pistons; G. H. Dyer Co., Cambridge, Mass.—pistons, reamers, Ford engine stands etc. Great Western Mfg. Co., La Porte, Ind.—wire wheels. (see also page 823.)

CHART NO. 366—Racing Bodies Reduce Wind Resistance and Weight.

*Note: This list was prepared sometime ago.

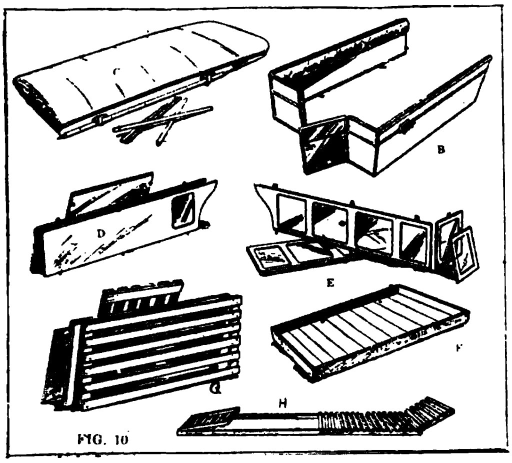


FIG. 10

Combination Bodies For The Ford.

A considerable amount of ingenuity has been expended by an English concern in designing, constructing and standardizing a convertible utility car, with the results as shown in the illustrations, which are from the Autocar, London.

The illustrations figs. 3 to 9, show how the body work in its various forms is built up, and how the car is capable of being turned into many uses that will appeal especially to those who live in country districts and have to rely upon their own means of transport. The farmer, too, would doubtless find all types of bodywork of use at various times, especially when there is a labor shortage.

To refer to the illustrations, these are almost self-explanatory, and although the sketches show actually six cars in one, this number does not represent the maximum of types which can be arranged.

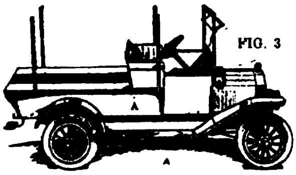


FIG. 3

The detachable parts of the different bodies are shown in fig. 10. In certain cases individual pieces have more than one use. The seat backs used for the wagonette and the station omnibus also form a part of the sides of the closed van, and for the latter the same canopy and upright are used. Instead of the upper half door and rear panels of the station omnibus, the van has a back panel hinged at the top, two supports being provided to hold it open when required.

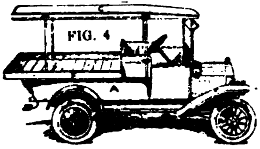


FIG. 4

The illustration, fig. 3, shows the chassis and the base fixed thereto, which forms the ground work of all the variations. The base (A) includes the seat for the driver and his companion.

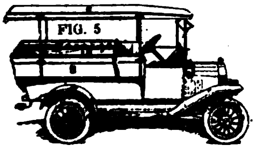


FIG. 5

The various bodies which can be built up on this groundwork are as follows: Wagonette, closed van, station omnibus, flat lorry or luggage cart, dray for live stock, such as sheep and pigs, hay and straw wagon for several kinds of bulky goods.

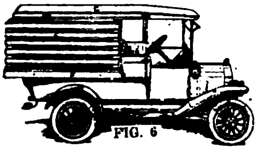


FIG. 6

The different types can be readily made from the detachable components, and it is a matter of only a few moments to change over from any one style to another. The upright for the canopy top of the wagonette and station omnibus are used to support the rack of the hay and straw wagon, though when the last named is used an additional pair of supports can be fitted. The station omnibus body has double doors, for the base carries permanently a half door at the back of the well, and the upper half for the omnibus use is attached to the detachable panels; the half doors are bolted together in use so as to form a single unit.

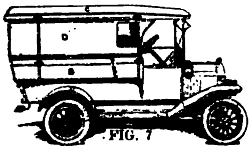


FIG. 7

Fig. 4—The Flat Lorry made up of the Base A, the Float F, the Uprights and the Canopy C.

Fig. 5—The Wagonette, consisting of the Base A and the Parts B and C.

Fig. 6—The Live Stock Dray having lattice placed on A and float F. The back is a hinged panel for loading.

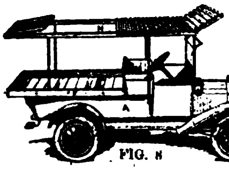


FIG. 8

Fig. 7—The Closed Van for perishable Goods made up of Parts B, C and D.

Fig. 8—Hay and Straw Wagon made up of A and the Parts F and H with the Canopy uprights.

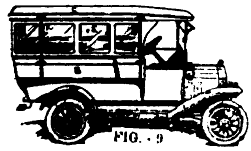
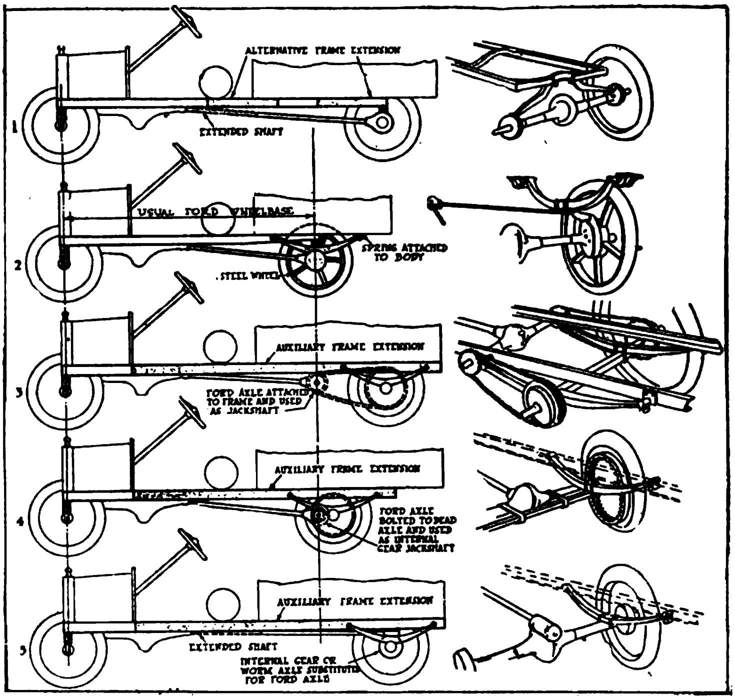


FIG. 9

Fig. 9—The Station Omnibus with glass sides consisting of A, B, C and E.

CHART NO. 367—Combinations of Bodies as Applied to the Ford Chassis.


1
ALTERNATIVE FRAME EXTENSION
EXTENDED SHAFT
2
USUAL FORD WHEELBASE
SPRING ATTACHED TO BODY
STEEL WHEEL
3
AUXILIARY FRAME EXTENSION
FORD AXLE ATTACHED TO FRAME AND USED AS JACKSHAFT
4
AUXILIARY FRAME EXTENSION
FORD AXLE BOLTED TO DEAD AXLE AND USED AS INTERNAL GEAR JACKSHAFT
5
AUXILIARY FRAME EXTENSION
EXTENDED SHAFT
INTERNAL GEAR OR WORM AXLE SUBSTITUTED FOR FORD AXLE

The five general types of Ford adapters, classified according to what parts of the Ford are retained in the converted vehicle, shown in elementary side and perspective sketches to indicate the changes made. The shaded portions indicate those parts which are added. Note that the Ford wheelbase is increased in all five classes except the second.

In No. 1 the Ford rear axle and spring are retained. The wheelbase is increased by the introduction of a frame section either at some point near the center or at the extreme rear. An additional piece of driveshaft of the same length as the increase in the Ford wheelbase is used to transmit the power to the rear axle.

In No. 2 the additional load capacity is taken care of through the use of steel wheels with housings carried on roller bearings independent of the Ford axle, which is used intact. Supplementary side springs attached to the body are employed.

In No. 3 the Ford axle is used as a jackshaft for a chain-driven rear-end truck assembly in unit with a frame extension.

In No. 4 the Ford axle is employed as a jackshaft for an internal-gear axle unit.

In No. 5 the entire Ford rear end is replaced by a truck frame addition and axle which may be driven either by worm or internal gears.

Commercial Applications of the Ford Chassis.

The Ford is being rapidly adapted to a variety of commercial uses. In the illustrations, figures 1 to 5, show **the five general methods used to increase the load carrying capacity.**

Carrying capacity. The use of these rear axle attachments, shown in figs. 2 to 5, usually give a capacity of about a ton, ninety per cent of the load being carried on the heavy rear axle of the truck attachment. The gear ratio is generally about 6 or 7 to one, thus decreasing the speed, and increasing the power and hill climbing ability. A speed of 15 to 18 miles an hour can usually be obtained with a one-ton truck adapter.

The method shown in fig. 1, which merely changes the length of the frame, and uses the standard Ford rear axle system, is only suitable for those having light, but bulky loads to carry—such as, millinery.

Overloading the engine. The engine will not be overloaded, when used to pull one of these one-ton trucks, because the gear ratio* is so lowered that it can cope with the added load successfully. However, these trucks should be driven with reasonable care, and kept in good running order. The radiator should be kept well filled with water, the fan belt kept tight, and the carbon removed and the valves ground more frequently than is necessary with less arduous pleasure car use.

Speed. If these truck attachments are not driven at a higher average speed than twelve or fifteen miles an hour, the life of the engine and the truck attachment will be greatly lengthened.

**Trailers.

Trailers are divided into two general classifications. The two-wheeled, or cart type; and the four-wheeled, or wagon type. The two-wheeled type is of course much simpler and does not require any steering gear, being simply attached to the rear by a tongue and flexible connection. The attachment is usually made to the center of the rear cross member of the chassis frame, where the spring is fastened—the spring clip bolts often being used to fasten the trailer connection.

On level country roads, Ford cars are sometimes used to pull from three to five of the light, two-wheeled trailers. When much used for pulling trailers, it is advisable to change the bevel gear and pinion in the rear axle, so that a gear ratio of 4 to 1 can be obtained. This lessens the strains on the engine, transmission, and other parts of the power plant.

The capacity of the two-wheeled trailer, is usually about half a ton, although some are made of three-fourths ton capacity.

The capacity of the four-wheeled type of trailer, is usually one ton or more. But a one-ton trailer is about as large as should be used in connection with a Ford car.

Speed with trailer attached is but little below that of usual touring car speed. Twenty miles an hour is usual speed.

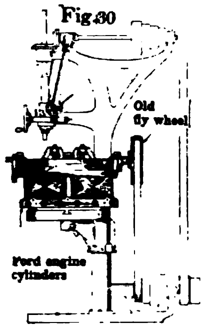
Load distribution, on two-wheeled trailers should be divided evenly in front of and behind the axle. Otherwise, severe strains will be placed on the connection between the car and the trailer, and the car may have to carry part of the load.

The coupling, or connection, between the car and trailer should be quickly detachable and provided with a cushion spring to absorb jerks and shocks when starting and stopping.

There are many firms who supply fittings for converting Fords for commercial use. One is the Unity Motor Truck Co. of Cleveland, Ohio, who manufacture fittings for converting a Ford into a 1250 lbs. truck or delivery wagon. The claim is that conversion can be made in 2 hours without drilling any holes.

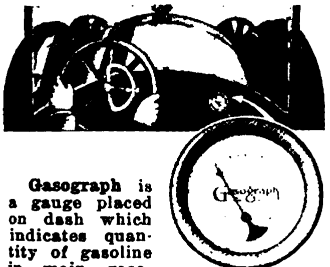
CHART NO. 368—Converting the Ford for Commercial Use.
(Motor Age.) *Usually 4 to 1, sometimes 6 or 7 to 1. **See also page 746.

Fig.30

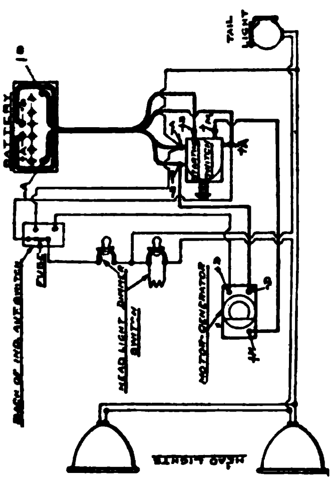


Ford main bearings, connecting-rod bearings or oversize pistons can be run or worn in by bolting the cylinder block to the drill-press table, with cylinder head removed and four ½-inch pieces under the corners between head and table to give clearance to pistons. A fly-wheel of the bolted-on type is drilled to fit the flange of the Ford crankshaft and bolted on.

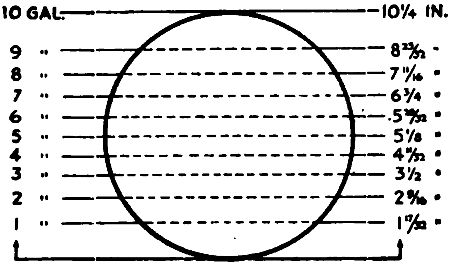
The table is turned so that fly-wheel lines up with the drive pulley of drill press and is then belted up. An elevating screw is used to tighten the belt.



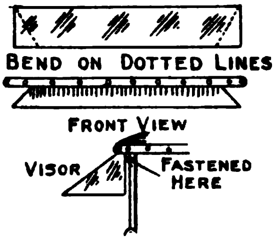
Gasograph is a gauge placed on dash which indicates quantity of gasoline in main gasoline tank. Adaptable for all cars using gravity or vacuum feed. Mf'g'd by New Standard Adding Machine Co., 3701-X, Forest Park Blvd., St. Louis.



Wiring diagram of Splitdorf electric system for Ford car.



Ford 10 gallon gasoline tank. Measurement of depth of gasoline in tank. (see also page 801.)



Visor Windshield Protector.

Snow on the windshield glass is the bane of winter motoring, and it is hardly satisfactory to tilt the glass so as to gaze between the windshield and the top, because too much snow and cold air rush in. But a cowl or visor can extend over the top glass of the windshield and will largely prevent the falling of snow on the glass.

To be effective, such a visor must extend from 6 to 10 inches in front of the glass. The lower it can be dropped without interfering with the vision of the driver, the better it will keep the snow and rain off the glass.

A straight piece of fibre or of thin sheet metal should have the corners bent at right angles, as shown by the dotted lines in the sketch. These side flaps keep the snow from blowing in at the sides and help to support the front edge of the visor. The rear of the visor should be fastened to the lower side of the front bow of the top, by means of a number of small, round head wood screws and washers. (Fordowner.)

Dimming Headlights.

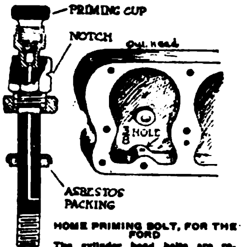
See page 795. **Ford engine stand,** see adv. Continental Auto Parts Co. **Cylinder reboring** device, see adv., So. Bend Lathe Works.

Ford Specialties.

Auto Parts Co., Providence, R. I., manufacture specialties for the Ford. Also Stevens Co., 375 Broadway, N. Y. Hill-Smith Metal Goods Co., Boston. G. H. Dyer, Cambridge, Mass. "Gemco" Mfg. Co., Milwaukee, Wiscn. McCodden Machine Works, St. Cloud, Minn. See also page 819. (Oversize pistons for Buick, Overland, Studebaker cars can also be had of G. H. Dyer, Cambridge, Mass.)

Firestone Demountable Rims and Wheels.

The advantages of demountable rims are explained on page 551. Rims are for 30x3½ tires all round which makes riding easy, longer life for tires and only one size tire and tube to bother with. The Firestone Tire and Rubber Co., Akron, Ohio, make this equipment for Ford and Chevrolet cars. The outfit consists of 5 rims for 30x3½ tires, 4 applied to wood wheels and 1 spare; 24 hub bolts and socket wrench. Wheels are made of second growth hickory, well seasoned and are furnished varnished natural wood or painted black. Price $20. per set f. o. b., Chicago.



HOME PRIMING BOLT, FOR THE FORD

The cylinder head bolts are removed, and the heads drilled as shown. The special bolts are then inserted, and permit the motor to be readily primed

Priming Cups.

A specially drilled bolt for the Ford cylinder head, by the use of which priming cups may be installed. Four of the capscrews holding the cylinder head to the cylinder are replaced by studs centrally drilled and carrying a priming cup on the upper end. The installation requires four ⅜-in. holes through the inner wall of the cylinder head to permit the priming gasoline to pass from the central passage of the bolt to the firing chamber. Home Light Co., 3353 Milwaukee Ave., Chicago.

*Tires.

Equal sized tires on Ford cars. Two Ford cars may be so changed that both can have three and one-half inch tires all around without extra expense, except the excess of tire size. Remove the wheels without hubs from the front of one car and the rear of the other. Place thirty by three rims all around on one car, and thirty by three and one-half on the other. Put thirty-one by three and one-half tires on the car with three inch rims, and thirty by three and one-half tires on the other car. This gives equal sized tires all around and extra size.

Spokes and rims can be had complete from Ford Co. ready to assemble to fit in hubs.

Extra oversize tires; the 30x3 front rim on a Ford will take a 31x3½ tire or a 32x4.

The 30x3½ rear rim will take a 31x4 or a 32x4½ tire. The 4 and 4½ inch of course will fit tight and are not recommended, but it can be put on by lapping the beads slightly.

CHART NO. 369—Desirable Accessories for the Ford; by writing the manufacturers, interesting descriptive catalogues will be mailed you if you mention where you saw the illustrations.

The speed of an engine can be determined by counting the number of impulses or movements one valve makes per minute. Every two revolutions of crankshaft, valve will move once, therefore if valve moves 200 times per minute, crankshaft would turn 400 times. This is about the limit one can count. Above this a speed indicator, page 700 or tachometer, page 921, is necessary. The Ford magneto should generate 7 volts at 400 r. p. —

*See page 364-A for tires on Ford enclosed cars.

Miscellaneous Ford Accessories.

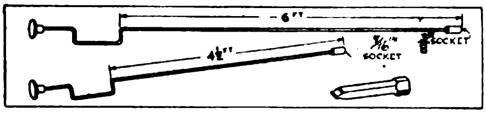


Fig. 2—Six-foot ⅝-in. socket wrench for universal flanges

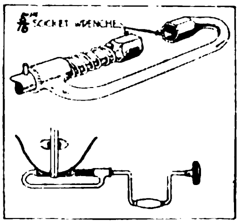


Fig. 3—Jew socket wrench for removing differential flange nuts in record time

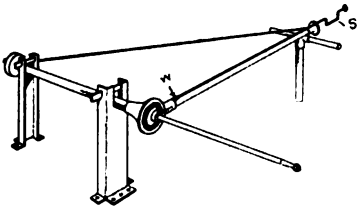


Fig. 5

Special Ford Wrenches.

Fig. 2. The 6 ft. one, with ⅝" socket wrench is used for removing the **universal flange** nuts from the rear without having to get under car. The 4½ ft. one, with 5/16" socket, is used to remove the **torque tube** retaining nuts after axle has been placed in the axle stand (fig. 5).

Fig. 3. Styled a jew speeder wrench; used in removing the 5/16" flange nuts and bolts holding the two halves of the axle housing together. (Motor World.)

Headlight control of a Ford, to keep the brilliancy or intensity of the lights equal at low or high engine speeds—see page 795.

Gasograph gauge, see page 823.

A spindle bushing remover is shown to the left. The knurled end is inserted through either bushing and pulled through until the expander slips over the inside end of the bushing. Then by tapping on the knurled end of the tool with a hammer the bushing is readily removed. By reversing the tool the opposite bushing is readily removed. Made of carbon steel, spring hardened. (G. H. Dyer, Cambridge, Mass.)

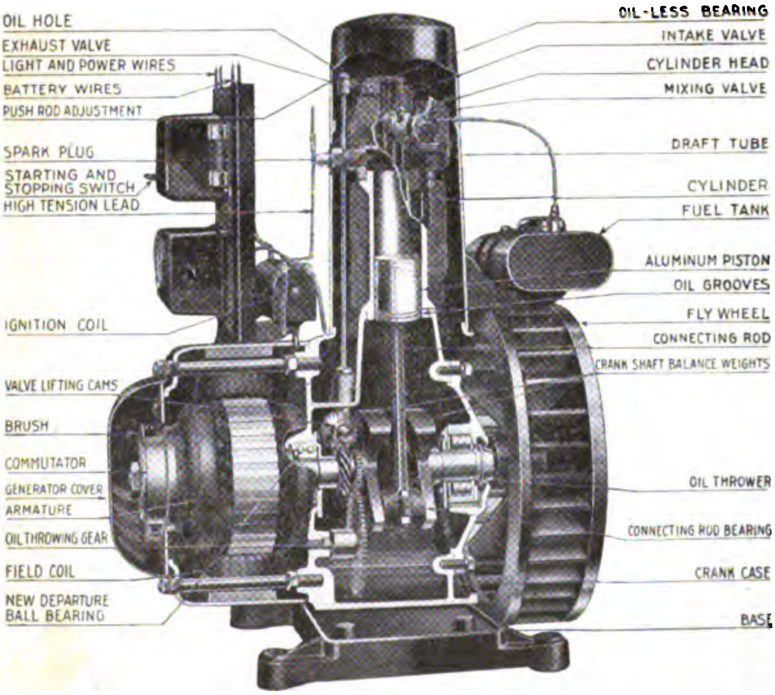
*The Delco-Light Plant.

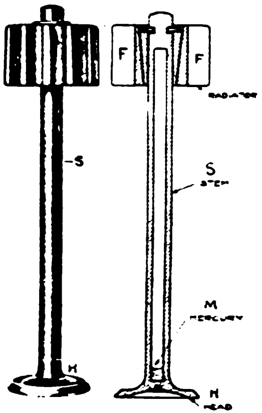
This subject is out of place here but will be shown, in order to give the reader an idea of the principle of construction of a modern farm lighting plant. The gasoline engine runs the dynamo and the dynamo charges the battery, which source of electric supply is used for lighting, power, etc. Manufactured by Domestic Engineering Co., Dayton, Ohio.

The mercury-cooled exhaust valve is used in some of the Delco farm lighting plant engines. With high duty internal combustion engines the exhaust valve is subjected to direct blasts of exhaust gases of about 1,800 deg. Fah. The only provision heretofore, for radiating the heat from valve head (H) and stem was through the valve guide, therefore the stem often became red hot—result, warping and loss of compression at valve seat.

Principle: The effect of the mercury contained within the valve is of course to transmit the heat from the hottest part of the valve up to the portion of the valve stem, which is exposed to the atmosphere, and which has a series of aluminum radiating fins (F) connected therewith, to facilitate the cooling of the valve.

The mercury (M) under normal temperature is in liquid state and rests at bottom of valve stem—as heat is absorbed by valve stem and transmitted to the mercury, the mercury is vaporized and immediately rises until coming into contact with the cooler part of the valve stem, when it will undoubtedly condense and flow back to the bottom of the stem to again be vaporized and repeat the previous operation.





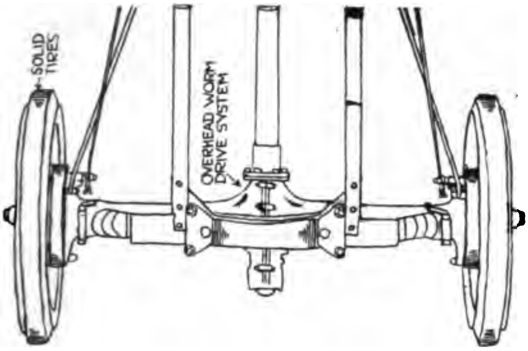
Mercury cooled exhaust valve.

CHART NO. 369A—Miscellaneous Ford Accessories. Delco-Light Plant.

*The Delco plant is well suited for automobile storage battery charging and lighting of garages.

Ford Truck.

The Ford truck is rated at 1-ton capacity and has pneumatic tires in front and solids in rear; it has overhead worm drive.



The chassis layout is very simple and reveals throughout how characteristics of Ford passenger cars have been developed to meet truck requirements. The change has been made principally in the rear part.

*Ford Truck Features.

Engine	3¾ by 4
Cylinders	L-Head
Gearset	Planetary
Drive	Worm
Front tires	30 by 3
Rear	32 by 3 Solid
Wheelbase	123
Load capacity	1 Ton
Price, chassis	$600

The distinctive features of the truck, aside from its use of the model T engine and the planetary gearset, are the overhead worm drive, use of solid tires in the rear and pneumatic tires in front, and its electric headlight equipment operated from the Ford magneto in the same way as it is now being furnished on the Ford passenger cars.

The engine is a four-cylinder block unit, with 3¾ x 4-in. L-head cylinders, with the valves on the right (same as in model T).

The crankshaft operates on three bearings and the camshaft is driven by spur-gears.

Cooling is by thermo-syphon with a fan behind the radiator, which is a tubular type.

Ignition is by single low tension magneto incorporated in the flywheel, and this same magneto operates two electric headlights.

The tail and side lights are oil.

The carburetor is a Holley instrument having a hot-air fitting which clamps over the exhaust manifold, giving a complete supply of heated air for cold weather evaporation. There is a dash carburetor adjustment controlling the needle valve. **Lubrication** is by gravity, with the oil carried to the front end of the engine and the timing gears by means of the flywheel, through the oil tube, after which it returns by gravity to the flywheel casing in the crankshaft.

The clutch is a multiple disc in oil, delivering the drive to a two-speed planetary gearset in unit with the engine. From here the final drive is by means of a propeller shaft and overhead worm.

The ratio in the worm gear is 7.25 to 1, giving a total gear ratio in low of 19.9 to 1, and a total ratio in reverse of 29 to 1.

From the worm the drive transmission passes through the bevel gear differential and semi-floating rear axle to the rear wheels.

The propulsion stresses are taken through radius rods which are fastened by means of pivot connections at the outer ends of the rear axle and through the tube which surrounds the propeller shaft. The driving torque is taken through the torsion tube which surrounds the propeller shaft.

The springs are the same as those used in the Ford passenger car excepting that they are made heavier in the rear to withstand a great load. This is a transverse type having an arch in the center.

The tire equipment is solid in the rear and pneumatic in the front, in both cases the tires being of the single type. Those used in the rear are 32 by 3 in. and those in the front are 30 by 3 in.

The wheels are wood artillery type with oval spokes and the brakes are the same as in the Ford T passenger car with the service brakes on the transmission, and the hand brake on the rear wheels.

The transmission drive-shaft brake is an external contracting type and the hand brake is an internal expanding on the rear wheels.

The steering gear is mounted on the left and control system is the standard Ford layout with three pedals and the brake lever. (Automobile & Automotive Industries.)

Dodge Light Delivery.

The specifications are similar to those of the standard passenger car, except that various parts have been strengthened.

The gasoline tank is beneath the driver's seat, and the steering wheel has been set at a higher angle to give a greater loading space.

Maximum load	1000 to 1500 lbs.
Tires	33 x 4
Loading space	72 x 43 in.
Wheelbase	114 in.
Clutch	dry plate
Gear ratio	4 to 1
Body	steel 54 in. high

Ford Engine In a Boat.

Length of boat suggested 20 to 22 ft. by 5 ft. beam and 1 ft. draft, the latter being for the hull only. The over-all draft or water the boat draws is determined by the size of the propeller. If there are obstructions in the water where boat is to be used, then better fit some form of skeg or protection below the propeller.

In mounting the engine fit strong oak cross-members in the engine compartment and fasten it in place with lag screws using the same brackets fastened to the engine. **Leave the transmission attached** and mount the powerplant so it will be level when the boat is in the water and under way. Boats rise out of the water when traveling fast, so you must make allowance for this. The engine will oil better when on a level. Proper adjustment can be made with shims under it.

The illustration shows a cranking device so the engine can be started from the seat. Arrange to drive a centrifugal or gear pump to force the cooling water around the jackets. Be careful not to get this pump too large, or the engine will be overcooled. Arrange to run some of the overflow water into the exhaust pipe, a foot or more from the engine, which will help to muffle the noise.

It is hard to give specific propeller dimensions, but if built somewhat after the design shown, one having a diameter of 15 in., three blades and a pitch of 22 in. would be about right. (Motor Age.)

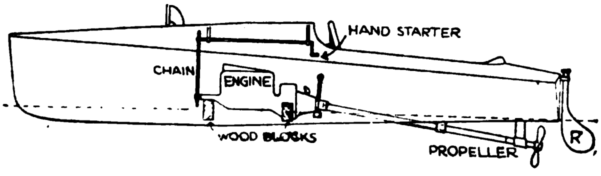
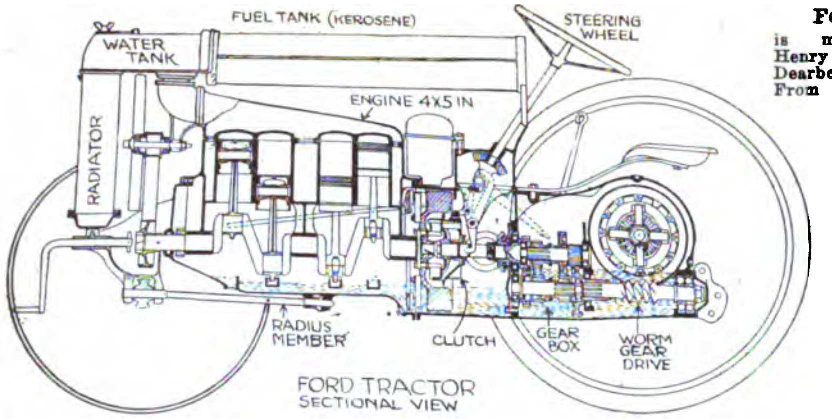


CHART NO. 370—Ford Truck. Dodge Light Delivery. Ford Engine Fitted To a Motor Boat.

---

*__Ford truck__ is now $550 with 32x3½ solid tires rear, and 30x3 pneumatic front, or $590 with pneumatic tire 32x4½ rear and 30x3½ front with demountable clincher rims. **Oil in Ford truck differential** should be level w upper oil plug. Mobiloil C, or 600 heavy transmission oil should be used. **Timken roller bearings** are no in front wheels of Sedans, Coupes and Trucks.



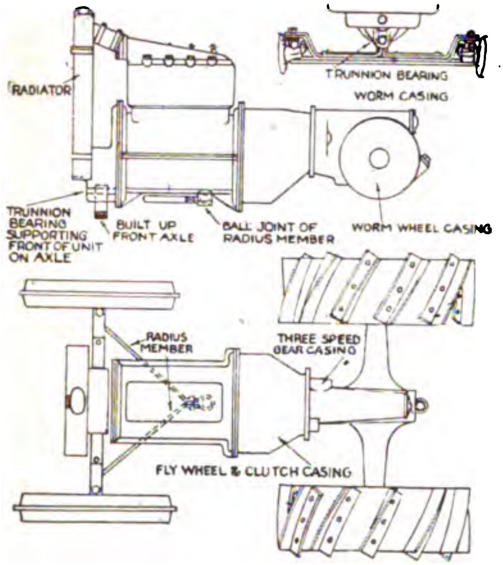
FORD TRACTOR SECTIONAL VIEW

Ford Tractor

is manufactured by Henry Ford & Son, Dearborn, Michigan. From an engineering standpoint the Ford tractor differs and possesses characteristics which distinguish it from others.

The crank case, gear box and axle housing serve also as the frame of the machine. The weight is 2,500 lbs.

Engine—4 cylinder, 4 in. bore by 5 in. stroke. L-head block type, having a displacement of 251.8 cu. in. Delivers 22 h. p. at 1,000 r.p.m. This is with kerosene and at compression of 60 lbs.



Valves have a clear diameter of 1⅛ in. and a lift of 5/16 in.

Valve timing is as follows: Intake opens 10 degrees after top center and closes 40 degrees after bottom center; exhaust opens 45 degrees before bottom and closes on top.

Fuel is carried to an overhead kerosene tank having a capacity of 21½ gallons. For starting, gasoline is used, and a gasoline tank holding 1 quart.

Cooling by thermo-syphon. Water carried in an 11 gallon tank. A four blade fan is used.

Ignition by fly wheel magneto. There are ten magnets clamped to fly wheel which rotate behind the stationary armature.

Voltage of magneto varies with speed of engine from 6 to 14 volts. 14 volts at 1,000 r.p.m.

A high tension coil is used. The timer and distributor are driven by a vertical shaft through mitre gears from cam shaft.

Carburetion is by a Holley vaporizer—chart 872.

Oiling is constant level splash. Capacity of system is 2½ gallons.

Drive from engine, through multiple disc clutch running in oil. There are 17 tempered steel discs in clutch with face of 1 1/16 inch.

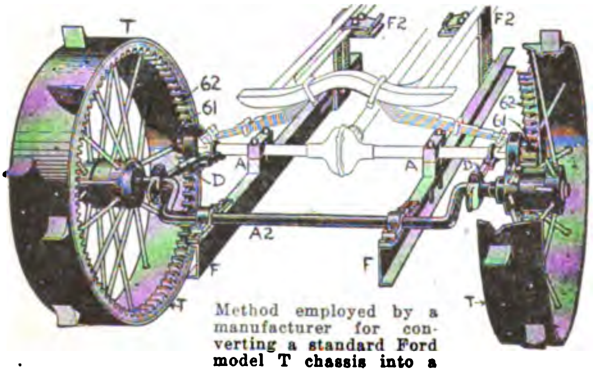
The outside diameter of discs is 7 in. and are held in engagement by six 80-lb. springs, giving total pressure of 480 lbs.

The clutchshaft or driveshaft is supported by a pilot bearing at the rear end of the crankshaft and carries the constant mesh gear for the three-speed gearbox. This is on the upper shaft of the gearbox, and the lower shaft is direct-connected to the worm which provides the final drive. By means of the combination of the reductions in the gearbox and in the worm gear, which latter has a ratio of 17:5:1, the following total reductions are obtained:

Gear	Ratio	Miles per hour at 1000 r.p.m. of crankshaft
High	18.25-1	6.83
Low	85-1	1.34
Reverse	48-1	2.60
Plowing (intermediate)	46-1	2.70

The worm gear is of undermounted type. It comprises a 60-deg., double-thread straight worm having a pitch of 1.2 in. At the rear end the worm shaft is supported in a duplex radial and thrust bearing. The worm is made of chrome vanadium steel and the worm wheel of aluminum bronze, which is composed of 10 per cent aluminum and 90 per cent copper.

The worm wheel is secured to the differential housing by twelve bolts. The differential, which is a four-pinion type, transmits the drive to the semi-floating axle. The driving wheels are mounted on the shaft by means of a slotted, tapered hub filling provided with a flange drilled for four heavy cap screws. The hub piece is splined at the axle connection, to render the transmission of the driving torque more secure.



Method employed by a manufacturer for converting a standard Ford model T chassis into a tractor.

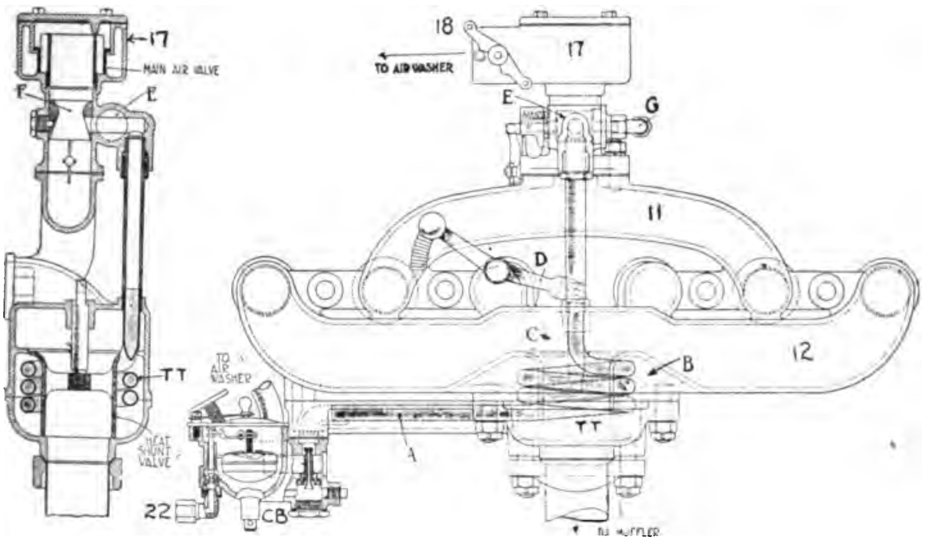
Steering is through a bevel gear sector and pinion, with a ball-end drop arm connecting through a large rod to the front axle cross arm.

The driving wheels are 42 in. in diameter and are provided with suitable traction lugs on the rims. The best shape of lugs is one of the details which is engaging the attention of the engineers at present, a self-cleaning lug being the object aimed at.

Road clearance is 11 inches. Lowest point being the fly wheel housing.

Crank case can be dropped while tractor is standing on its wheels, only part necessary to remove is the radius rod. Tractor will turn in a radius of 21 feet. **Transmission** is three speed and reverse, gear type.

CHART NO. 371—Ford Tractor.



*Holley Kerosene Vaporizer.

The Holley vaporizer puts kerosene into the proper vaporized condition by mixing it with the correct percentage of air to take care of the kerosene vapor after it has been formed, and by means of heat applied in a progressive degree converts this primary mixture of kerosene and air into a mixed vaporous condition.

Heat Is Regulated.

Probably the most notable point of departure of this system as compared with others is the method of shunting the heat, which enables the efficient use of the different fuels under different temperatures.

Another point which should be noted in the Holley system is the use of the thin-walled brass tubing for vaporizing the fuel. This is made as light as it is commercially possible to obtain it, and by means of the rapid flow of heat possible through and around this thin tubing it is possible to use one float chamber and to shift from gasoline to kerosene in from 15 to 30 sec. after starting.

It has been the experience of the Holley company that slight alterations in engine design are necessary for the use of kerosene. The compression can vary from 45 to 70 lb., according to the efficiency of the radiator. On the average engine a compression of about 55 lb. is best for kerosene.

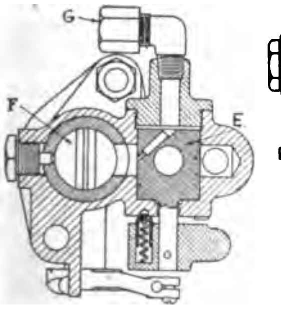
Only One Float Chamber.

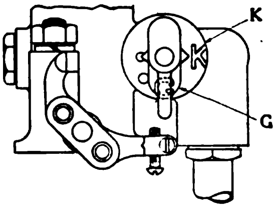
On the particular type to be described there is but one float chamber, and this is for kerosene.

The gasoline for starting is admitted by means of a mixing valve or jet which is only in operation for a short time and which corresponds very closely to the choke tube used on gasoline carburetors for starting purposes.

The kerosene enters the float chambers at (22) and is controlled by means of an ordinary type of float mechanism.

From the float chamber the kerosene passes through an orifice controlled by a needle valve (N) to the top of the jet, where it is atomized by approximately 10 per cent of the total air required for combustion. This action of atomizing is done by the ordinary type of spray nozzle, the air being induced by the suction of the engine.





The mixture of atomized fuel and air is then drawn through the vapor tube (A) situated in the heater chamber of the special exhaust manifold (B), where the fuel is vaporized in its passage through the coiled tube (TT). The relatively rich mixture is heated progressively higher in temperature in its passage through the vapor tube, and by applying the heat at progressive stages, deposits due to decomposition products are avoided.

The temperature of the rich vapor can be regulated by means of the shunt valve (C) controlled by the lever (D), whereby

—continued on chart 373.

CHART NO. 372—Holley Kerosene Vaporizer Used on Ford Tractor.

*See page 831 for Kerosene difficulties and page 754 for other Kerosene Carburetors.

—Holley vaporizer continued.

more or less of the hot exhaust gases can be caused to come into direct contact with the vapor tube, thereby compensating for variations in fuel or operating conditions, such as a cold, wet day and a dry, hot day.

From the heater chamber the vapor tube issues and is connected through the shifter valve (E) to the venturi tube situated in the mixer chamber (F).

Cold Air Dilutes Mixture.

At the venturi tube the rich vapor is diluted with the additional relatively cold air required to form a combustible mixture. In other words, this is the point where the action of the ordinary carburetor is paralleled quite closely, with the exception that instead of gasoline, and air being mixed, a relatively rich mixture of fuel plus 10 per cent of the necessary air is admitted in place of the fuel alone, and in addition the other 90 per cent of the air required is supplied. The additional air required is admitted through a special form of air valve which governs the air admitted in accordance with the throttle position and requirements of the engine.

After the mixture of rich vapor and cold air has taken place the combined mixture passes the throttle into the inlet manifold and thus enters the engine.

The shifter valve (E) performs a double function. In one position it serves for starting purposes using gasoline as fuel, at the same time closing off communication between the vapor tube and the mixer chamber. It is to all intentions a simple two-way valve which, in one position, allows the suction of the engine to fall on the starting generator in communication with the gasoline reserve tank, and in the other position is in communication with the coil vaporizng tube above described.

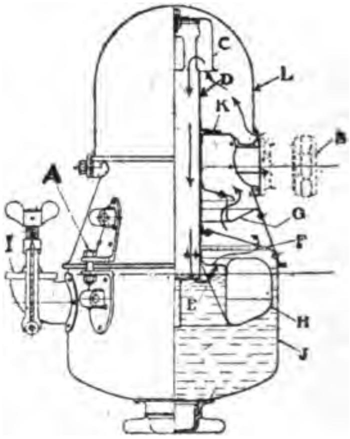
The gasoline for starting is supplied from a small auxiliary tank connected with the connection (G) on the shifter valve housing, passing through the valve into the venturi tube, where it meets the air induced by the suction of the engine in its passage into the intake manifold. The regular running position is, of course, provided when the shifter valve is turned to allow direct communication with the coil vapor tube.

Air Washer.

In England, where this carburetor is in use to a great extent an air washer is employed in connection with the vaporizer. It is a separate and distinct device. The scope of this air washer is to remove any deleterious matter in suspension, such as dust, which is inimical to the engine, from the air to be mixed with the fuel and passed to the combustion chamber. But cars employed in ordinary service, where dust is not generally encountered, at least not in material quantities, need not be fitted with this auxiliary.

The air washer consist of a tank (J) fig. 5 carrying a quantity of water through which the air destined for admixture with the fuel is forced.

The air enters through a tube (D) attached to a float (H), the lower end of the tube being immersed about ¼ in. This depth is maintained by the float, above which is set a number of baffles (FG) to prevent large drops of water passing with the cleaned air from the scrubber. Owing to the cap (C) fragments of dirt are unable to enter the tube, while this cap furthermore acts as an air cut-off valve when the water has fallen low, automatically stopping the engine and warning the driver that the tank (J) requires a fresh water charge. If this cannot be given at the moment, the water filler (I) may be used as an emergency air inlet. Further protection to the upper end of the float tube is assured by the housing (L), so that all air is compelled to pass between this housing and the upper tank at low velocity.



Experience has proved that this wet method of cleaning the air is preferable to all others, because it brings about the complete removal of all dust associated with the air, requires very little power for its operation, is of comparatively small dimensions, and imparts a slight increase of power delivered by the engine when an exhaust-heated carburetion system is employed.

Water consumption naturally varies obviously, being high when low humidity combined with a high-air temperature conditions obtain, and vice versa.

So far as the trials have been carried, it would seem as if the water consumption ranges from 1-10 lb. to 1-20 lb. per horse-power per hour—in the case of a 20 h.p. machine from 1 lb. to 2 lb. per hour—with humidity ranging from 25 to 75 per cent and an air temperature of 80 degrees Fahr.

Since no water leaves the washer in the form of drops, but only in the form of saturation of the air, this water consumption cannot be reduced by mechanical agency. It may be pointed out that the air leaving the washer is not completely saturated.

The washer is applicable to any carburetor, whether exhaust heated or otherwise. In the latter instance no adjustment is required. Test has shown that with gasoline no difference to engine power output is noticeable by the introduction of the washer, it merely overcomes all risk of dust entering the cylinder.

HART NO. 373—Holley Kerosene Vaporizer—continued. **Air Washer.**

nother popular Air Washer is manufactured by The Wilcox-Bennett Co., Minneapolis, Minn.

INSTRUCTION No. 49-A.

ADDENDA: Additional matter on Tractors, Tractor Engines, Truck Engines and Repairs. Truck and Tractor Engine Ignition. Governors. Motorcycles. Repairing Tops.

Tractor Drive Methods.

This subject was dealt with on page 752. Under this head, additional information will be given on it.

For a tractor to travel over all kinds of roads it is necessary that it lay its own track or road in many instances. Therefore some means of presenting a large surface to the ground on which the weight may be supported, to prevent sinking into soft soil, must be provided. There are several methods employed, the most common being the **flat wheel tread, chain tread and rail track tread.**

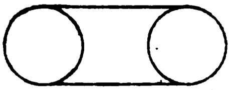


Fig. 1 *Chain tread*

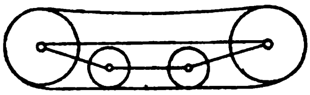


Fig 2 *Rail track.*

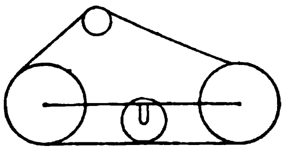


Fig. 3 *semi-rail-track*

The flat wheel tread is the type shown on page 826 as used on the Ford and "Twin City," page 830, and other light tractors. On some tractor wheels the **projecting treads are detachable** and can be removed and deep or shallow treads applied according to the condition of the soil.

The chain tread is furnished by stretching a movable chain of various constructions over and around two wheels, which has the effect of presenting considerable flat surface to the ground between the two points of support. The tread is made to move or crawl by driving the sprocket support wheels which have cogged teeth to engage cogged teeth on the inner face of the chain—see fig. 1.

The above would be termed the chain tread, because the weight of the tractor is supported on the wheels with direct ground contact with the chain tread and minus the rail track.

The rail track tread is represented by the Caterpillar and Cleveland, which differs widely in principle to that of the "flat wheel tread" and differs from the chain tread in that a "rail track" is provided.

The point aimed at by the designers is to secure not merely that the entire weight of the machine shall be evenly supported on the large surface of the chains, but that there shall be no arching of the chains, and that the wheels which do the driving shall carry little or no weight, whilst the wheels which carry the weight not only do no driving at all, but run on **rails** and are not affected by the pull of the chain, and this result is secured in the following manner:

The weight of the tractor is supported on two axles or trucks, which carry, the one the driving or track sprocket wheel and the other an idle wheel of similar size, and the axles also support a beam or connecting bar beneath which are mounted a series of smaller idle or truck track wheels with smooth faces, formed to run on the rails or track.

The weight of the machine is carried on wheels which run on rails or track.

The chain itself, it will be noted, (see fig. 4), is driven by the track sprocket which is driven by the engine through a countershaft and gear transmission. As the chain tread (also called track link shoes), are made to revolve over the drive sprocket and track idler, then it will be noted, the tractor is really running on rails or a track, which are being laid down for the track wheels to revolve upon.

Although there are numerous methods of design employed for the construction of this chain or outer shoe, as it is termed, the principle is very much the same. **The difference however, between the "chain tread" and the "rail track" tread** is made quite clear in the illustrations fig. 1 and fig. 2.

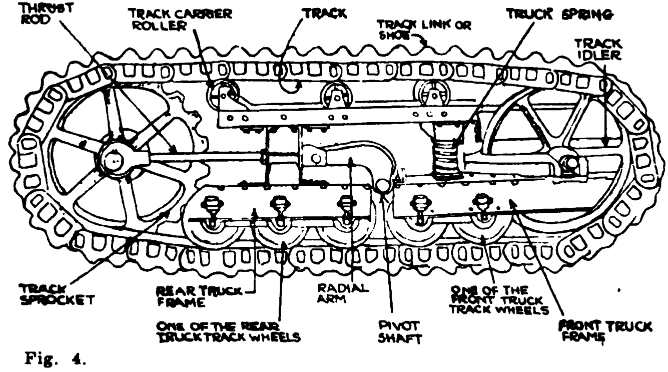


Fig. 4.

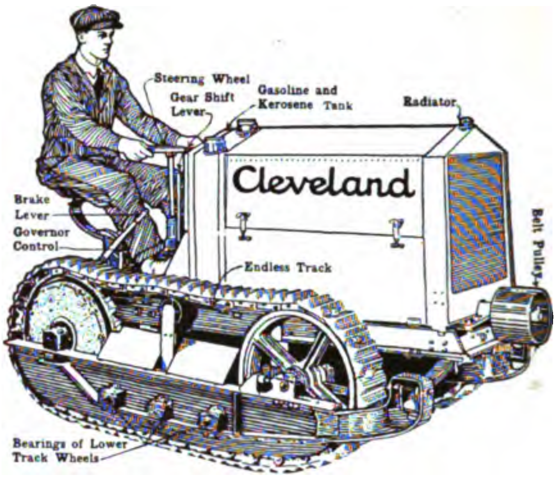
The track-laying portion of a Holt caterpillar. The rear sprocket transmits the drive pulling on the portion of chain which is lying flat on the ground. Weight of tractor is carried by the 5 truck track wheels.

---

*See also pages 752 and 753.

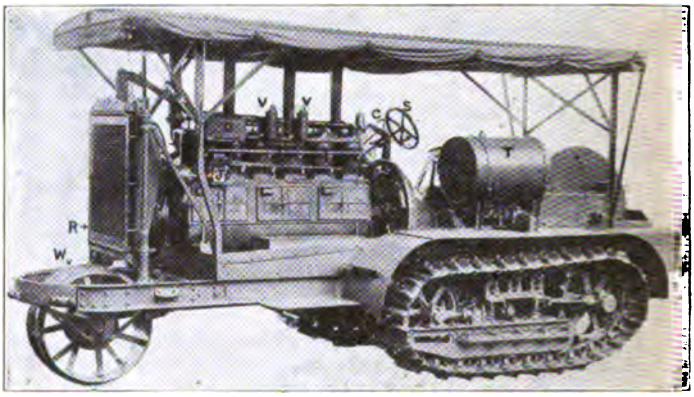
The Cleveland Light Tractor.

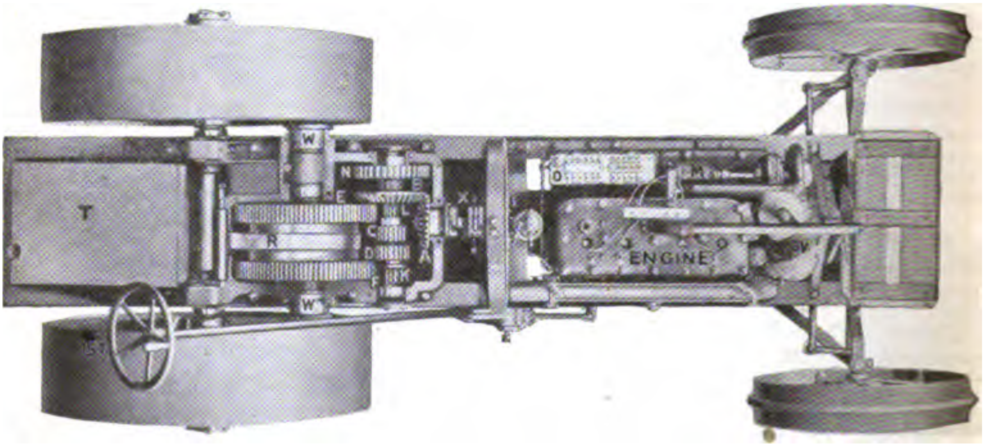
Drive, "rail-track," page 829. Also termed the "crawler" principle of drive. See page 831 for description. Note pulley in front for **belt power** use. Also note **driving sprocket** is in the rear.



The Caterpillar 120 H. P. Military Type Tractor.

Drive, typical "rail-track," see page 829, fig. 4. Drive sprocket is driven by chains from a countershaft which is driven by a gear transmission and clutch. **Engine,** six cylinder; **vacuum fuel feed** (V) method employed as explained on page 165; gasoline or kerosene is used—fuel tank is (T). A mechanical **oiler** (O), similar to system explained on page 195 is employed. **Ignition** by K. W. **magneto** (J). A throttling type **governor** for controlling speed of engine through carburetor is employed. In fact the principle of operation of engine is similar to an automobile engine. Access to crank case is through hand hole plates (L). **Steering** by wheel (S) which operates wheel (W). **Radiator** (R). **Spark** and **throttle** control (O).





Tractor Transmission—"Twin City-16" as an Example.

B—is a band **brake** around drum which contains the **differential** gears. **Belt power** is obtained by a shaft (not shown) above and forward, driven from gear (N).

Clutch is the contracting band type which fits over projecting rim (C) on fly wheel page 832. It is operated from seat by shifting clutch yoke (X) above. For **high speed,** (2¾ m.p.h.), the power is transmitted through gear (A), then (B) through sliding gear (D) to (F), thence to bull pinions on end of shafts (W), which drives the internal gear in tho wheels. **For low speed (2 m.p.h.),** sliding pinion (O) meshes with (E). **For reverse** (2¾ m.p.h.), power is delivered from (D) to (F) through a floating pinion mounted in the upper **half** of the transmission (not shown). The **floating pinion** is also a sliding pinion, so that when in **neutral** position it is slid out of mesh with **gear** (F), **but** continues to run idle with pinion (D) **when in neutral** (as shown in position (D) is now).

CHART NO. 374—Example of Modern Light Tractors for General Tractor and Belt Use: The Cleveland and Twin City "16." The Caterpillar Tractor.

See also pages 752 and 753.

The Transmission of Power

is usually from engine to clutch, thence to a gear transmission, thence to a countershaft, from which the drive sprocket is driven by a chain. On wheel driven types there is often an internal gear drive in the wheel.

On several new machines a regular truck gearset is employed with three ratios, this being coupled to a jackshaft incorporating a constant large reduction through a pair of spur gears. More than one machine is using a worm gear ahead of the last spur train, so that the worm speed is the same as that of the crankshaft on high gear. There are usually, 2 or 3 speeds plus a reversing gear which allows the different ratios to be used ahead or astern.

Clutches—many are still using the old style expanding or band clutch. The cone or disk clutch is coming in favor.

A clutch lever for throwing out the clutch is used more than clutch pedal, however, many are now adding the clutch foot pedal.

Tractor Engines.

Is similar in many respects to an automobile engine. The same principle of ignition, timing gears, valves etc. are used. The engine is built much heavier however and runs slower—therefore greater heat is generated and more cooling surface is necessary.

Tractor Engine Ignition.

See page 832.

Kerosene Difficulties.

Kerosene is being used to a great extent, but gasoline is generally used to start on. Very few tractors operate on kerosene alone with any degree of satisfaction.

Kerosene needs more than a heated carburetor—the mixture itself must be heated to prevent condensation in the manifold, as explained on pages 157, 155 and 160. Also see the Holley, page 827.

Where kerosene is used, on account of this condensation, one manufacturer clearly states in his instructions: "If kerosene is used; it will be absolutely necessary that oil in the crank case of the engine be changed after every 20 hours running." This is due to the fact that the kerosene condenses if not properly heated, and mixes with the lubricating oil and thins it down to such an extent it loses its lubricating qualities.

Experiments conducted by the Holley company bear out the fact that once the kerosene has been thoroughly vaporized (heated) and mixed with a sufficient quantity of air to take the vapor by means of heat applied in the proper manner, it is possible to carry the charge several feet without experiencing condensation.

When engine smokes excessively, from the exhaust and smoke is black, then this indicates that the fuel is not being properly combusted, either by feeding too great a quantity at carburetor or not being properly vaporized.

Tractor Steering.

When the three wheel is used—the third wheel is operated for steering.

Where four wheels are used as on the Cleveland, for example; then the steering gear arrangement is as follows; a train of gears are operated by the steering wheel, and these in turn apply a brake to one side or the other of the axle. This slows up the crawler belt of one side of the machine, allowing the other to go ahead at a speed ratio corresponding to the resistance placed upon the opposite member by the brake pressure. When the brake is applied altogether so that one belt or chain crawler is stopped, the reduction is 1½ to ½, or, in other words, 3 to 1, through the differential gears. The actual drive connection between the rear axle and the crawler wheel is by an internal gear. The emergency brake is applied against a band mounted on the outside of the differential drum.

The Cleveland Tractor.

It weighs 2750 lb. and is characterized by its small size, being but 52 in. long by 50 wide. It is rated at 12 hp. at the drawbar and 20 hp. at the pulley, and with its crawler or creeping type of tread, 600 sq. in. of traction surface are provided. The overall length of the tractor is 96 in.

As may be seen from the illustrations the **powerplant** is set well back toward the center of the crawler drive; thus the traction surface carries the weight well toward its center so that a maximum tractive effort can be secured. The **radiator,** which is at the front of the tractor, is the only part projecting forward of the driving wheels, and at the rear the driver is seated slightly behind the rear axle.

The frame of the tractor is made up of two side bars mounted on trunnions at the rear axle, and the crank case transmission and rear axle housings also have their value as structural supports. The effect of three-point suspension is secured by having the rear connections of the side bars mounted on trunnions, and in front these are connected with the cross spring by shackles. This gives a flexible drive which allows the tractor to work at advantage on unequal stretches of ground.

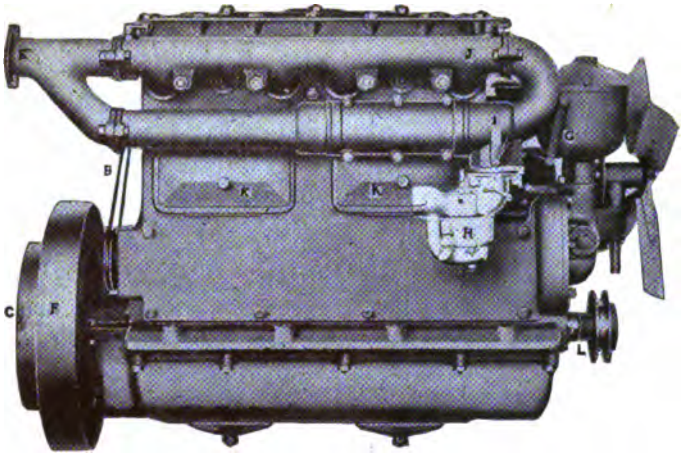
The engine is a Buda model R, 3½ by 5¼. The characteristics of this engine are such that with the gear ratio used on the tractor an efficient working speed is obtained at 3½ m.p.h., with a maximum working speed of 4 m.p.h. The revolutions per minute of the engine are 1450 at 4 m.p.h. and 1272 at 3½ m.p.h.

From the engine the drive is transmitted through a *Borg & Beck dry-plate clutch to a transmission unit developed by the Cleveland Tractor Co. provided with one speed forward and one reverse. The reduction is 25 to 1 in either case. From this unit the drive is transmitted through bevel gears to the axle, which transmits the torque to the crawler mechanism. The belt pulley is 8 in. in diameter and has a 6 in. face. The width of the track is 6 in. and the length, 50 in., giving 300 sq. in. of traction surface on each side of the machine.

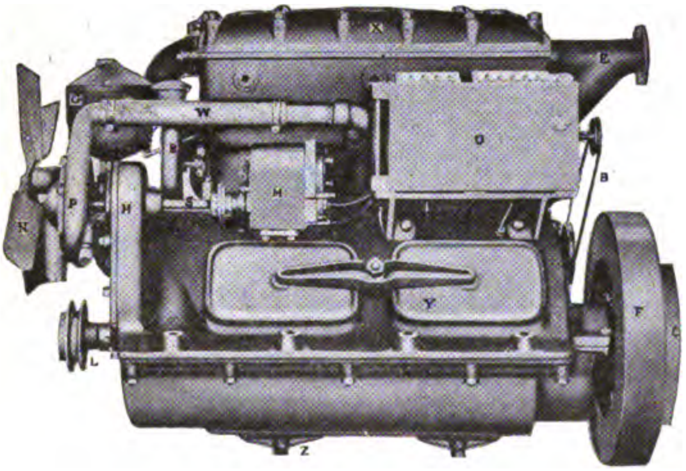
The carburetor is a Kingston fitted with a Bennett air washer, the magneto an Eisemann, and the radiator a built-up cellular type. The gasoline tank is mounted just behind the engine and forward of the steering wheel, the latter being mounted upon a vertical steering post with the driver seated on a support mounted at the end of a flat steel bracket which acts as a spring.

---

*See page 42, 688, 842.



Valve, exhaust and inlet side: **C**—clutch member on fly wheel (F); **K**—valve covers; **H**—carburetor; **I**—inlet manifold around one branch of exhaust manifold which heats mixture; **J-E**—exhaust manifold; **G**—governor—the lever operates butterfly valve in carburetor; **L**—fan belt.



Magneto and lubricating side: **M**—magneto, K. W. high tension; **S**—shaft driving magneto, which is driven by gear in gear case (H); **O**—force feed lubricator driven by belt (B)—see page 195 for the "mechanical type;" **P**—water pump; **R**—breather pipe; **Y**—hand hole plates to reach bearings, and through which pistons and connecting rods can be removed; **G**—governor, "fly ball" or "centrifugal" type.

The Twin City "16" Tractor Engine.

Carburetion; gasoline to start on and kerosene, alcohol, distillates of 42° Baume or higher, and flash point of not over 120° F. **Fuel tanks;** kerosene 33 gallon; gasoline 8 gal. A Stewart vacuum system is used, see page 165. **Cylinders;** 4, L-type, 5" base x 7½" stroke. **Speed of engine,** 650 to 750 r.p.m.; **Valves,** on the side; **Ignition,** K. W., model TK, enclosed type.

Tractor Ignition.

Other K. W. magnetos which are used on large tractor engines are models as follows:

Model H—(4 magnets); for engines having normal speed greater than 300 r.p.m., and which have provision for starting or can be cranked at a fair speed by hand.

Model HK—(4 magnets); for use on engines the same as model H, but has the impulse starter for hot starting spark.

Model HT—(5 magnets); for use on engines having normal speed of less than 300 r.p.m., and which have provision for starting with air, etc., and will furnish a hot spark as low as 30 r.p.m. and will fire any sort of fuel:

Model HTK—(5 magnets); for use on engines the same as model HT, but impulse starter allows engine to be started by hand if air supply is lost, or for use on large engines which previously had to be started with battery ignition.

K. W. Impulse Starter.

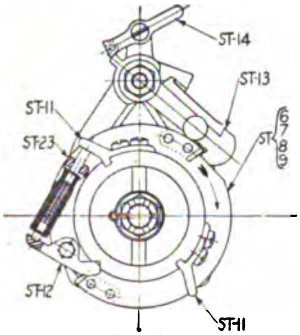


Fig. 10. The K. W. impulse starter is located between magneto drive and armature. When engine is cranked, the armature is held stationary, while energy is being stored in compression spring—which is then tripped.

This attachment allows the engine to be started regardless of cranking speed, as the rotor of magneto (inductor type) is held stationary while the coupling is moving 80 degrees, then is tripped and thrown ahead at the rate of 500 r.p.m., assuring a very hot spark for starting. When engine comes up to speed, the starting device is automatically thrown out of action, and simply revolves with shaft. The magneto is driven at a fixed speed.

To time a K. W. high tension magneto—see pages 288 and 296. **To time with impulse starter:** (1)—place piston 8 to 5° past top center on power stroke: (2)—mount and connect magneto so that the tripping mechanism will not trip the impulse starting device until engine is from 3° to 5° past dead center on firing stroke.

In starting engine up, place circuit breaker in retarded position and press finger down on trigger (ST-14), which releases hook dog (ST-13), so that when ratchet notch on magneto comes around in the right position the hook dog (ST-13) will engage in the ratchet notch, holding magneto back from rotating about 80°, or until engine is from 3° to 5° past top firing center, in which position, if the magneto is properly placed on the engine, the knock-off cams (ST-11) will disengage hook dog (ST-13), thus allowing magneto to jump suddenly forward at a high rate of speed, creating a hot spark in the cylinder under compression, thus firing the engine, no matter how slowly the fly-wheel is turned over.

If these instructions are not clear, then put the ratchet catch (ST-13) out of engagement and time magneto as shown on pages 288 and 296. **Cams,** see page 298, fig. 9. See also pages 256, 264, 928.

HART NO. 375—Example of a Modern Tractor Engine. Tractor Engine Ignition—the K. W.

he modern tractor engine differs from the automobile engine; in that it is of heavier construction, long stroke, lower speed governor which throttles the carburetor. Will operate on kerosene or gasoline. With these exceptions the principle is the same. See also page 833, the Waukesha, an engine used on light tractors.

Waukesha 4 Cylinder Truck and Light Tractor Engine.

F—valve spring; D—valve spring retainer; C—valve spring cap; E—lifter adjusting screw; G—lock nut; J—valve lifter; K—valve guide; L—cam on cam shaft; A—valve cap; B—copper gasket; I—valve seat; H—valve face; water circulating pump on left.

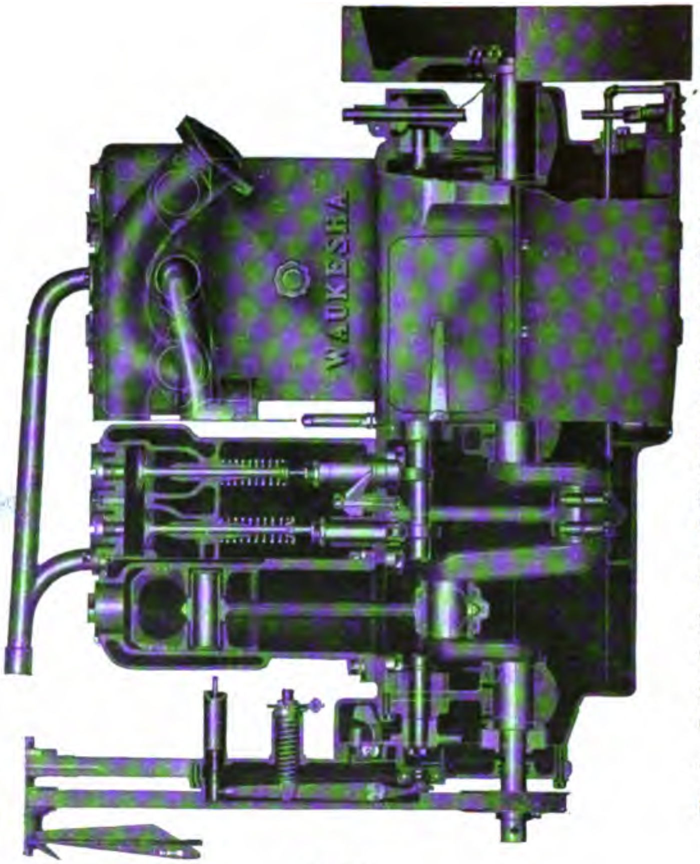


Fig. 2: Sectional side view of Waukesha 4 cyl. engine, showing operation and interior construction. Note governor fulcrum and oil pump, latter being at lower fly wheel end.

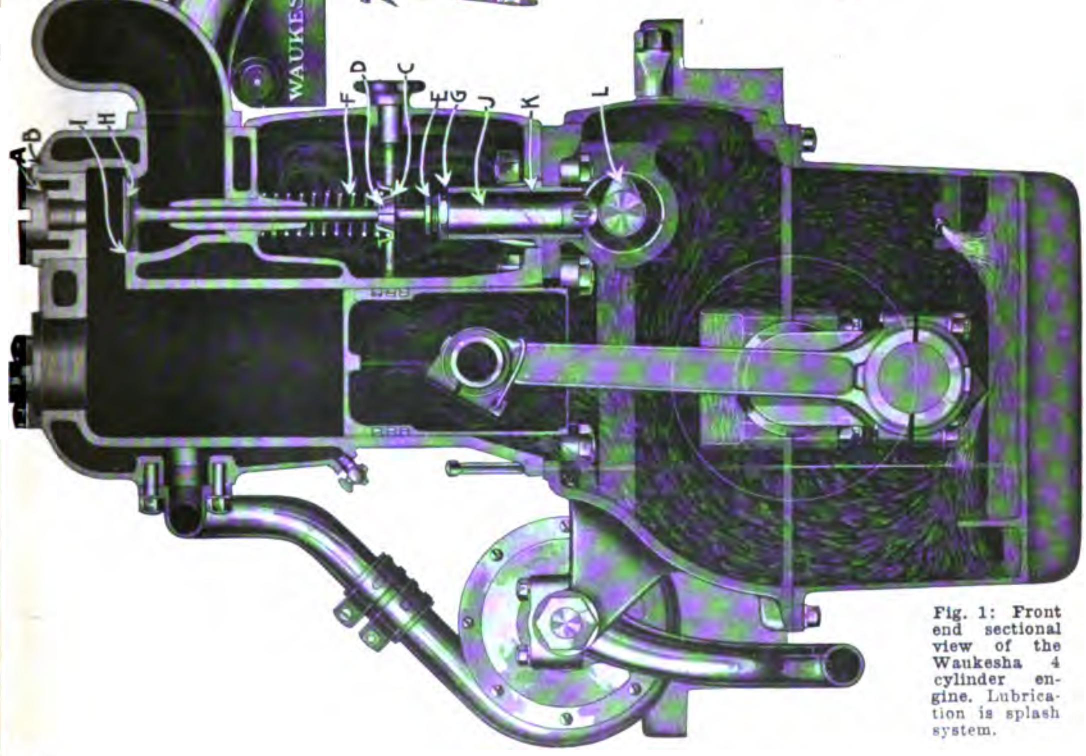
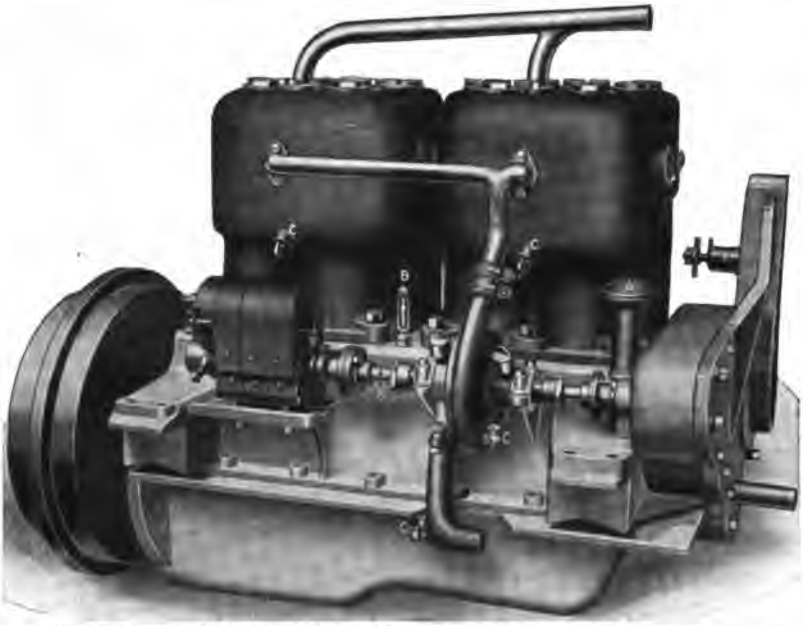


Fig. 1: Front end sectional view of the Waukesha 4 cylinder engine. Lubrication is splash system.

CHART NO. 376—Example of Truck and Light Tractor Engine; The Waukesha. The Waukesha is used on the Gramm, Buford, Chase, Acason and many other makes of Trucks and a number of light Tractors.



How to Put Oil in Engine.

Remove breather cap (A—fig. 3). Pour oil into breather until needle float in gauge (B) comes up to within ¼ inch of top of glass.

Remove crank case hand hole plate (fig. 6, page 836) and fill each trough under connecting rods.

Use a thinner oil in winter and a heavier one in summer.

C—fig. 2, are water drains for cleaning sediment or rust from water jacket and circulating water pump, also for draining in winter to prevent freezing.

Fig. 3—Right side of Waukesha truck engine—note magneto (also see page 285—type used on this engine. Also see page 312 for setting the magneto). Circulating pump and magneto are driven from gear (C) fig. 5, page 835, also see page 312.

Engine Oiling System Inspection.

Drain oil—remove oil pan so you can inspect thoroughly. When system is running properly a stream of oil is constantly forced through holes A, B, C and D, fig 4. Inspect each oil hole carefully and see that they are not clogged or partially clogged up. A piece of waste or dirt may have worked into one of the holes preventing the entire flow of oil.

To test oil flow; with some oil in oil pan, turn oil pump shaft with a pair of pliers as shown. If the oil discharges through all of the holes then the pump and oil line are o. k.

Clean the screen (S), fig. 4. In fact this should be cleaned often with gasoline, say every 3 months if engine is run regularly every day. When removing for cleaning, be sure to retain supporting spring inside and make sure of an oil-tight joint being established between oil pump screen flange gasket and crank case (see fig. 7, page 836).

The oil pump is located at the lower left side of engine, when in rear of it—see fig. 7, page 836 and fig. 2, page 833. It is driven by cam shaft, see fig. 2, page 833.

Above is oiling system of the models L-M-P-N-R-S-O; SU4R, RU4R, LU4, MU4 and PU4 Waukesha engine.

Kinds of Oil To Use.

Pleasure car; thin. Truck; thicker. Tractor (gasoline); heavy. Tractor (kerosene); heaviest. When kerosene is used clean oil pan often and put in fresh oil—see page 831.

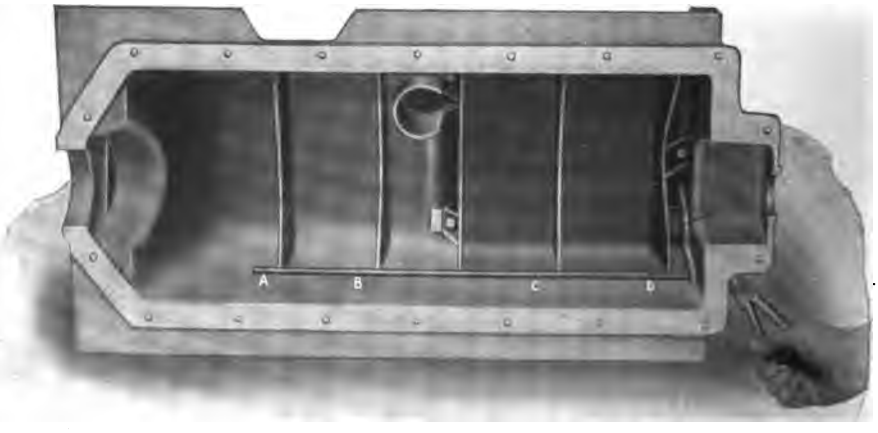


Fig. 4—Oil pan removed.

CHART NO. 377—Caring For and Repairing a Truck and Light Tractor Engine.—Waukesha used an Example.

To Get At The Gears.

Take off front gear cover carefully. See that no bolts or nuts are mislaid or lost. Also be careful, in taking off the ball-race on the governor, to see that none of the bearings drop out. Do not put the front gear cover on again until you are absolutely sure every one of the ball bearings is in place, and that the paper gasket is in good condition to prevent oil leaks.

Be sure to mark the gears. It is very important that the gears be kept in exactly the same position as when you received the engine. Mark each gear as shown in fig. 5—that is, mark the center gear A-B-C as shown, then mark the same letter on the gear that connects at the particular point. In putting the gears on again see that the connections are A-A, B-B, C-C, just as marked. In marking the gears put the letter on the cog of one gear and on the corresponding space where this tooth meshes on the connecting gear just as shown in fig. 5A.

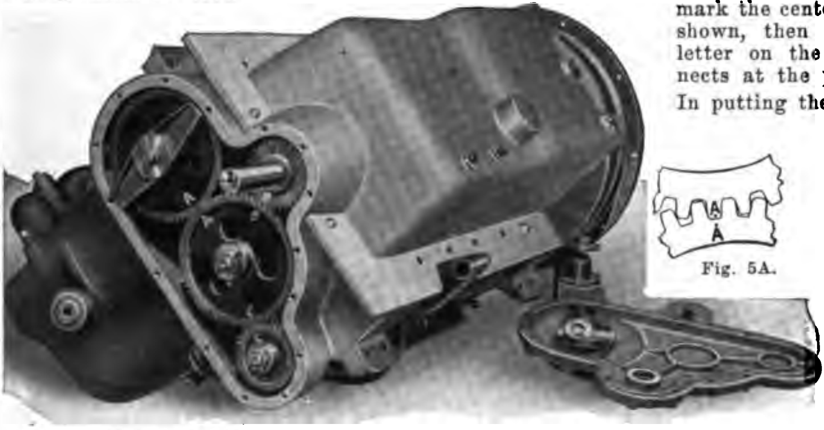


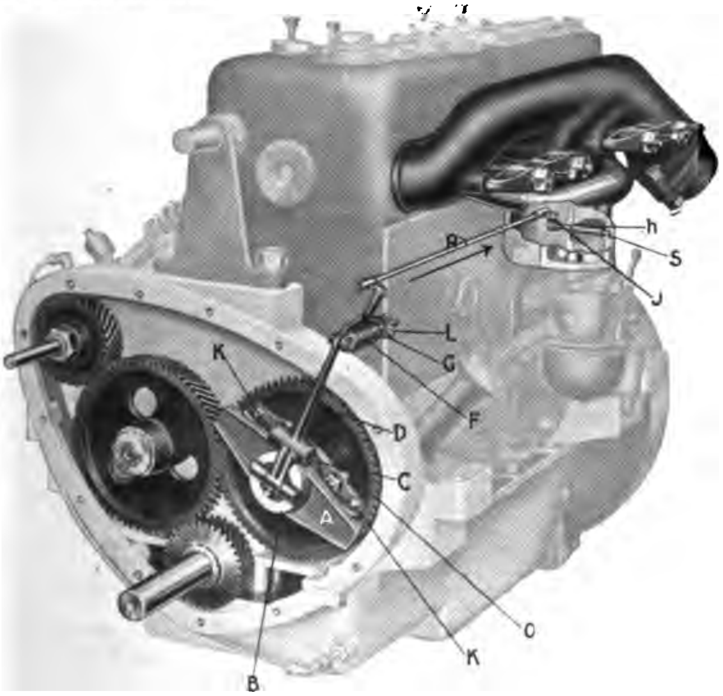
Fig. 5A.

Fig. 5—Showing how the gears are arranged. C—drives the magneto and circulating pump; next gear to it is idler gear, placed between the small crankshaft gear B and C; the gear on which governor is attached is the gear which drives the cam shaft and oil pump and is driven by the idler gear also. Therefore cam shaft gear revolves ½ the speed of crank shaft gear.

Operation of Waukesha Governor.

Two circular weights back in the case behind gear "O" fig. 6, are held by—and swivel about—the two pins marked "K." These weights fly out at speed; moving part "A" outward. This action presses the ball bearing thrust contained in retainer "B" outward in proportion.

The lever "D" swivels on fulcrum "C." The movement of "A" causes a movement of rod "R" in direction indicated by arrow. The movement of rod "R" closes valve "H" which is of the butterfly type and swivels on shaft "S."



The adjustment for speed is made by turning screw "L." Turning "L" in direction indicated by arrow causes engine to speed up, while turning "L" in opposite direction causes engine to slow down.

The governor is locked by locking nut "G." It is further possible to lock and seal the whole arrangement by passing a seal wire through hole in spring housing, and through hole in nut "G."

"F" is a spring, the tension of which governs speed of engine. The governor is the throttling type and controls the amount of gas to cylinder—therefore it would be termed a throttling type of governor of the centrifugal type —but by weights instead of balls.

Fig. 6—Front view of engine with gear case cover removed showing gears and governor action. The large idler gear between the two small gears drives the large cam gear and magneto and circulating pump gear.

CHART NO. 378—Waukesha Truck and Light Tractor Engine—continued.

*How to Time the Valves.

All Waukesha engines have cylinders numbered 1-2-3-4 starting at gear end and reading toward flywheel end.

Timing By Fly Wheel Marks.

As a rule the fly wheels are marked as to when the valves should open. The following method is applied in case the flywheel and the timing gears are not marked.

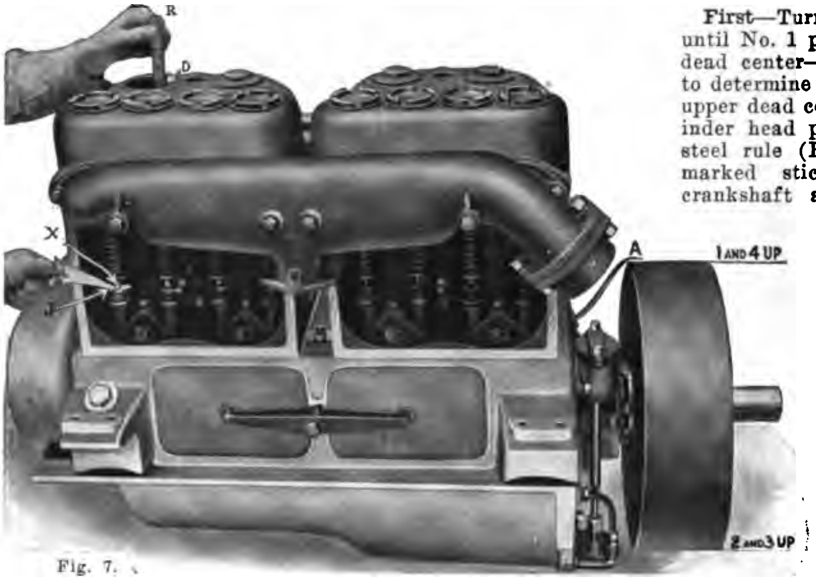


Fig. 7.

First—Turn the engine over until No. 1 piston is on upper dead center—fig. 8. In order to determine when piston is at upper dead center, remove cylinder head plug and insert a steel rule (R) fig. 7, or any marked stick. Rotate the crankshaft and watch while the rule (R) comes up. When it ceases to rise then the piston will be at upper dead center.

Draw two lines across the back side of the flywheel (fig. 8); next measure off 53 degrees on each side of the center line at the lower half of the flywheel.

Second—On the illustration fig. 7, note the pointer (A) (also called a trammel, see also page 105). This pointer points to the exact top center of the flywheel. The arrow on dead center line, fig. 8, shows where pointer (A) points, looking at the back side of the flywheel. Turn the engine over slowly until the arrow (A) points directly on line No. 3 as indicated in fig. 8.

Third—Remove the idler gear (A-B-C, page 835). See that the push rod (J, fig. 7) is in its lowest possible position. Place a thin piece of paper between the push rod (J) and the valve stem (X, fig. 7). Turn the cam shaft gear (see "O" fig. 6), slowly towards the right until the paper which is placed between the push rod (J) and the valve stem (X) is held tightly. Be sure that the valve stem (X) has not raised any. Also be sure that the cam shaft gear retains its position and that the piece of paper is still held tightly between the push rod and valve stem.

Fourth—Place wooden wedge between the cam shaft gear and the case to keep this setting. This will give you the free use of both hands to replace the idler gear. Replace the idler gear.

Fifth—Give the engine a slight turn (say about one-half inch on the flywheel); now see if the exhaust valve (X) has raised any. It should, if the above instructions have been carefully carried out. You can now replace the gear case cover and the cylinder head plug.

*Timing by Position of Piston.

If it is impossible to get at the flywheel, remove the cylinder head plug, insert a ruler as shown in fig. 7. When the upper dead center has been determined, measure the distance from the top of the piston to the top of the cylinder. For example, let us say it is 2 inches (see arrow marked D, fig. 7).

Now slowly turn the engine over until the distance from the top of the piston to the top of the cylinder measures 7⅝ inches. This means that the piston has made a drop of 5⅞ inches, at which place the exhaust valve (X) should just start to open. In order to set the valve and complete the timing refer to paragraphs, third, fourth and fifth above.

This setting pertains only to models L-LU4, M-MU4 and P-PU4.

For models O-OU4-OU4R, S-SU4-SU4R, R-RU4-RU4R, N-NU4-NU4R the piston should drop 4⅞ inches from upper dead center, that is the exhaust valve should open 50 degrees before the piston reaches the bottom dead center after the explosion has taken place.

For models T and TU4, B and BU4 the piston should drop 4.644 or 4 11/16 inches from upper dead center; or, the exhaust valve should open 45 degrees before the piston reaches the bottom dead center after the explosion has taken place.

In all events in resetting the valves, the magneto will have to be retimed; for this operation see page 312.

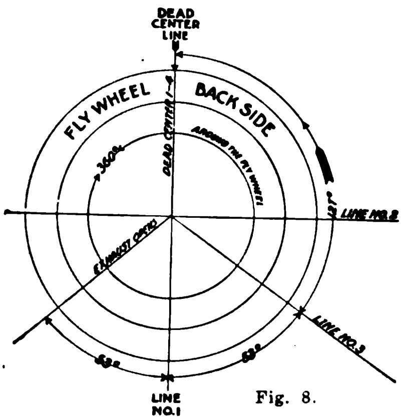


Fig. 8.

CHART NO. 379—Timing The Valves—Waukesha continued.

*See page 312 for timing the ignition or setting magneto.

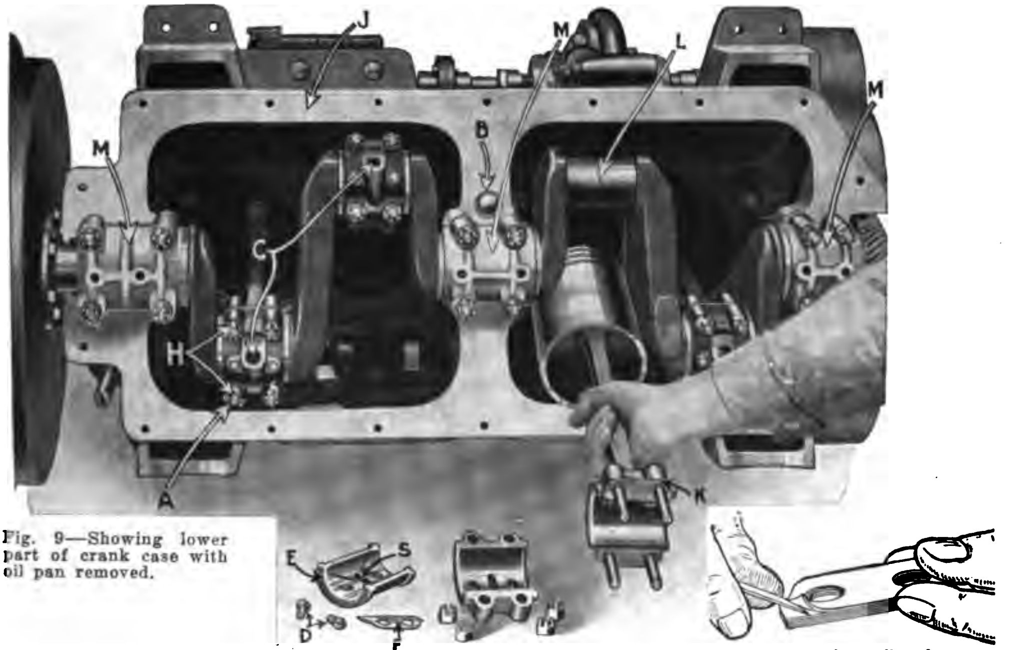


Fig. 9—Showing lower part of crank case with oil pan removed.

Fig. 10—Peeling off a laminated shim, per page 641.

How to Adjust Loose Connecting Rods and Main Bearings of Waukesha Engine.

Connecting rods and main bearings may be adjusted without taking the engine out of the chassis. However, this does not hold true where it is impossible to work at the engine from below.

The following instructions will give you a good idea how to proceed in order to properly adjust the connecting rods and main bearings in many of the modern engines.

First—Drain off the oil by removing the drain or pipe plugs from the bottom of the oil pan; then place a small lift jack under the pan to keep it from dropping before all the oil pan bolts that support it have been removed. It is advisable to tie up the oil float (B) as high as possible to prevent it from dropping into the oil pan while the latter is being removed (this can be done by unscrewing the holder of the oil gauge glass) and thus prevent the possibility of it being damaged or bent. This also makes it easier when you are ready to replace the oil pan. Open all four compression cups on top of cylinders.

Second—After removing pan scrape off the gasket from bottom edge (J) of crank case and clean away all dust and dirt so that it will not get into the bearings. Clean your hands and tools before working on the bearings and never use cotton waste or any rags which might leave shreds behind as these might cause serious trouble to the oiling system.

Third—When working on bearings it is a good plan to pull out the pistons and clean off the rings and piston heads. Always oil the piston rings before replacing the piston.

Fourth—Pull out the cotter pins (A) and unscrew the four nuts (H); (always use a socket wrench for this operation as open end wrenches are apt to destroy the nuts) when taking off the cap be careful not to lose any shims or liners (F) and keep them in place on K, until ready to remove them.

On later engines laminated shims are used between the connecting rods and their caps, allowing one to adjust the bearings to within .002 of an inch. Laminated shims vary in thickness, and are made up of a series of small shims—.002 of an inch in thickness—which are pressed together as one piece. In taking the loose play out of the bearings, one can peel these shims off (fig. 10) to any amount required to have a perfect adjustment on the bearings—never peel off any more of the shims at one time than is necessary. Take out the shims to the amount you think necessary to take up the wear, being careful to remove an equal amount of shims on each side of the cap.

Before replacing the cap, see that the thin shims are placed between two heavy ones with which the connecting rods are always supplied. Replace the cap and draw it up as tightly as possible, using all four nuts and drawing them up evenly and firmly.

Now try turning the engine over by hand in order to find out whether you have the bearings too tight or not. It should turn easily as this represents only one tight bearing; when this bearing is right loosen it, and proceed to fit the other bearings in the same manner.

After each bearing has been fitted and tested draw up firmly all the nuts and use new cotter pins only; never back up the nuts to insert the cotter pins—always draw up to the next notch and never use wire in the connecting rod nuts as it will interfere with the oiling system. Have the cotter pins well bent apart—so they cannot back out when engine runs.

CHART NO. 380—Adjusting Loose Connecting Rods and Main Bearings—Waukesha continued.

How to Replace Worn or Damaged Main Bearings.

First—Take the engine out of the tractor or chassis and before removing pan draw off all the oil. Refer to page 834 for instructions in removing oil pan.

Second—Take out all spark plugs, priming cups, etc., on top of cylinders. Now stand the engine on its head and place props under the engine arms to keep it from wabbling while work is being done.

Third—Remove the oil pan and take out all pistons and be sure that they are all marked so they will be put back into their respective places. Remove gear case as shown on page 835.

It is most important before removing the crank shaft to mark all the gears in accordance with instructions on page 835, otherwise there is a possibility of getting the engine out of time.

Take off the fly-wheel but be sure that you have it marked with the flange on the crank shaft, as it is very important that the fly-wheel is replaced in the same position as when you take it off.

Fourth—Take off the three main bearing caps (M, as illustrated on page 837) and remove the crank shaft. Stand the crank shaft up on end and place it safely aside as a fall might spring it out of shape and later you would wonder why the bearings could not be fitted. Remove idler gear marked A-B-C, page 835.

Take out the screws to remove the damaged bearing. Clean away all dirt and grit with gasoline; fit in one-half of the new bearing in the crank case. This operation is the same as described for replacing connecting rod bearings, page 837.

After bearing has been fitted in the crank case, replace crank shaft. Apply Prussian blue or red lead, to the crank shaft bearing surface and scrape off the "spottings" in the same way as in fitting new connecting rod bearings. Strict attention must be paid that the new bearing does not rest too high in the case so as to throw the other two bearings out of line, nor should the bearing be too low.

Should the bearing be too high, either the other two bearings will have to be raised by shimming them up, or the new bearing must be scraped until the three bearings are on the same level. **The crank shaft must fit the half of the main bearings in the crank case perfectly before you proceed to fit the caps.**

Always fit the rear main bearing cap first and tighten it up as much as possible without stripping the bolt threads. When the bearing has been properly fitted the crank shaft will permit moving with one hand. If the shaft cannot be turned with one hand the contact between the bearing surfaces is evidently too close, and the cap requires shimming. On the other hand, if the crank shaft moves too easily some shims must be removed to permit it to set closer.

After removing the cap observe whether the blue "spottings" indicate a full bearing the length of the cap. If they do not the bearing will have to be scraped. Lay the rear bearing aside and proceed to adjust the center bearing in the same manner. Repeat this operation with the front bearing, with the other two bearings laid aside.

When the proper results have been obtained with the bearings replace the idler gear and be sure that the connections A-A, B-B, C-C, correspond, as shown in cut on page 835.

You can now replace the caps and insert the cotter pins, or wire. **Be sure when you replace pistons** that the heads and the rings are free from grit and carbon, also oil each piston ring carefully.

Fifth—Oil the bearings well by means of an oil can and turn the engine over (by using the crank handle) several revolutions before replacing the oil pan.

Sixth—Are you sure that holes (C) in all four connecting rod bearing caps are facing direction engine runs? This is important because when the engine runs oil is forced into these holes to lubricate the bearings; if one of these holes should face in opposite direction that bearing would get practically no oil the bearing would heat up and soon cut out resulting in a costly repair.

Seventh—Refer to oiling system page 834, before replacing pan.

How to Replace Worn or Damaged Connecting Rod Bearings.

First—Remove oil pan as instructed on page 834; then take off the cap and pull out the piston as shown on page 837.

Second—Take out the screws (D) in order to remove bearing (E). Be sure to fit the bearing half with the large oil hole (S) in the cap, and the other half in the connecting rod (K).

The back side of the bearing must have a perfect or snug fit in the connecting rod, otherwise it will be impossible to get a perfect permanent bearing on the crank pin (L). Fitting the back of the bearing is practically on the same order as fitting the bearing to the crank pin. Using Prussian blue or red lead in the rod and cap will enable you to find the high spots between the cap and the bearings; these high spots must be draw filed—see pages 630 and 643.

Third—Put in the screws (D) very firmly and be sure that the heads are lower than the bearing surface so that they do not come in contact with the crank shaft. Next draw file across the top of the cap and the rod to have the bearing flush with same.

Fourth—Without replacing the piston in the cylinder fit the bearing to the crank pin (L); if the bearing is too wide the ends will have to be draw filed. Be careful not to file too much off. By applying Prussian blue or red lead to the crank pin surface it will enable you to fit the bearing to the pin to determine whether a perfect bearing surface is obtained. Remove the rod and observe whether the blue or red "spottings" indicate a bearing the full length of the cap. If they do not the babbit should be scraped until a perfect bearing surface is obtained.

Adjust the bearing to the crank pin so it can be moved to and fro freely, but at the same time it must not be loose. **Remove the connecting rod and replace piston and give the bearing the same adjustment as you did when the piston was out;** then turn the engine over by hand several times to make sure that no binding takes place.

Do not be afraid of getting the connecting rod bolts too tight as the shims under the cap will prevent the metal from being drawn into too close contact.

Governors.

Governors are extensively used on trucks, tractors, taxicabs, marine and stationary engines.

Purpose of the Governor.

There are two reasons for using a governor; one, to regulate the vehicle speed, the other to regulate the engine speed. Where it is desirable to limit only the vehicle speed of trucks, taxicabs, or even pleasure cars, the transmission or front wheel type of installation (fig. 1, page 840) is used. The governor is set at whatever speed the car owner desires, is then sealed and the driver can never exceed the speed for which the governor is set. The engine type of governor (fig. 2) is used to prevent undue racing of engine when changing gears or releasing the clutch. The average driver will work his engine at high speeds a great deal more than necessary, straining the entire mechanism of the car, and wasting both fuel and oil. By governing the engine speed, the vehicle speed is also limited.

Drive Methods.

Transmission drive—(fig. 1, page 840): With many models of trucks, taxicabs, fire apparatus and pleasure cars, it is more desirable to control the vehicle speed than the engine speed, thus leaving the engine absolutely unrestricted at any speed, except when in high gear. When this is done, the governor (G, page 840) is driven by means of a flexible shaft and tube (SH), and gears (K) (L) attached to transmission shaft or front wheel.

Engine drive—fig. 2: This type of governor regulates the number of revolutions of the engine, and will keep it running at a definite, safe speed regardless of the load it is pulling, even if the throttle is wide open. The regular **hand throttle lever or accelerator may be used for lower speeds.** Should the clutch be suddenly released when engine is pulling a load or running at maximum speed, the engine positively cannot race. The engine governor also limits the vehicle speed, because the engine cannot exceed the set speed.

Dual drive—fig. 4: To provide double protection the engine drive and transmission drive governor have been combined. When driving in high gear, only the vehicle speed will be controlled, but when the vehicle is stationary, or being driven in low gear, the governor throttle valve will close before a damaging engine speed is reached. The engine governor is set at a higher speed than when used singly. The most popular use of the dual type is for controlling the engines of fire trucks, army searchlights, etc., where the engines perform two kinds of work.

Care and Installation of Pierce Governor.

Mounting governor. Use thin gaskets of blotting paper only. **Don't use shellac**—it will cause the governor valve to stick.

Flexible drive shaft. There should be no bends in shaft within two inches from either end, nor should shaft be bent into a circle of less than ten inch radius. Make all bends as easy and large as possible.

Solid drive shaft. In mounting solid shaft, be sure that shaft ends properly engage in governor, right angle drive, and engine connection, lock nuts on tube are tight. Don't screw tube up tight enough to cause shaft or gears to bind.

Oiling governor equipment. Before the governor is put into active service, see that the case contains about four ounces of good light oil (light Polarine preferred) that is not affected by change in temperature. Put in one or two ounces of oil every thousand miles. Flexible shaft should be kept packed with Artic No. 3, or a good graphite grease, renewing same every two thousand miles. Oil gear bearings, right angle drives, or engine connections, each week through oil holes provided.

Loose connections. When driving gears or brackets are used, examine them regularly to see that none work loose and that gears are kept in perfect alignment and meshing properly. If a belt is used, keep it tight and free from oil or grease, to prevent slipping.

Regulating governor speed. Should it be desirable to change the speed adjustment, cut the wire that seals the adjusting screw and pull off the cap that it holds in place. The adjusting screw (A, fig. 3) will then be exposed. Turning this screw to the right or clockwise decreases the speed; turning to the left or anti-clockwise increases the speed. When proper adjustment has been made, replace cap and seal same, so that the adjustment cannot be tampered with or affected by vibration.

Note: The governor does not interfere with the regular spark or throttle levers, or with accelerator control by hand or foot—see paragraph "engine drive" above.

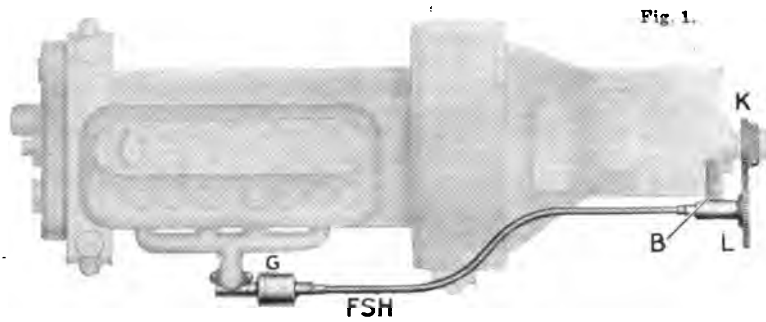


Fig. 1.

Fig. 1 — Governor (G) is driven from transmission, through flexible shaft (F. S. H.) and gears (K and L). Bracket (B) supports driven gear (L). Could be driven from front wheel.

Governor controls vehicle speed only, leaving engine free, except when high gear ratio is used.

Operation of Pierce Governor.

The governor valve box (fig. 2) is mounted between the carburetor and intake manifold and connected to the driving shaft by means of either a solid shaft (SSH-fig. 2) or a flexible shaft (SH-fig. 1), depending on type of installation.

Normally the butterfly valve (V fig. 3) is in a position that does not obstruct the flow of gas, but it closes so as to reduce the valve port area just as soon as the vehicle or engine reaches the predetermined speed. The valve is actuated by what is known as the flyball or centrifugal principle. On the controller shaft are two weights (W, fig. 3) which are so pivoted that as the velocity of the shaft increases they are swung outward, forcing a plunger (P, fig. 3) forward, which in turn closes the butterfly valve (V, fig. 3). The plunger is forced against a spring (S, fig. 3), calibrated to a standard pressure, so that as the speed is lessened the weights return to their original position and valve is again wide open.

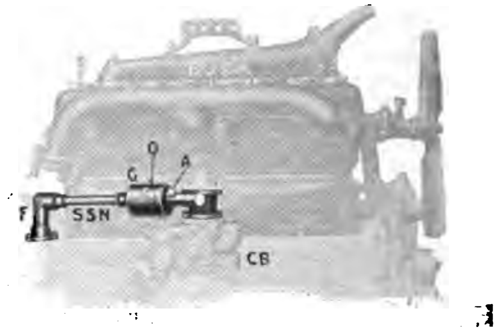


Fig. 2—Engine speed controlled by governor (G) driven from gear on cam-shaft through adapter (F) and solid shaft (S. S. H.). O—oil cup; A—adjusting screw and seal. Governor can be driven from any rotating part of engine.

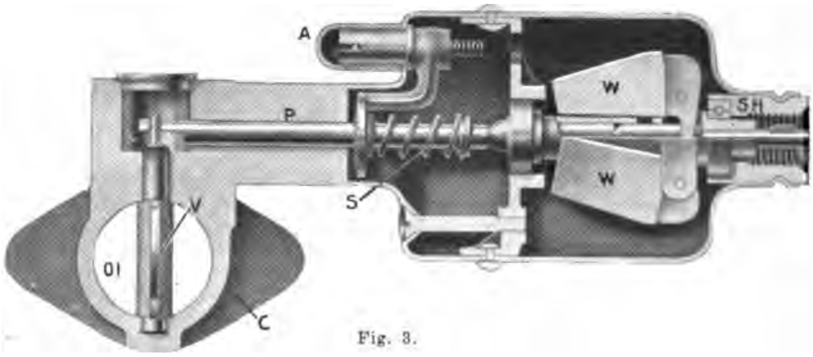


Fig. 3.

Fig. 3 — Cross section of Pierce governor; C—connects between flanges on inlet manifold and carburetor; OI — is passage opening for gas; V—butterfly valve; P—plunger operating valve bell crank; S — spring; A — screw for adjusting spring tension; W—centrifugal weights; SH—where driving shaft connects.

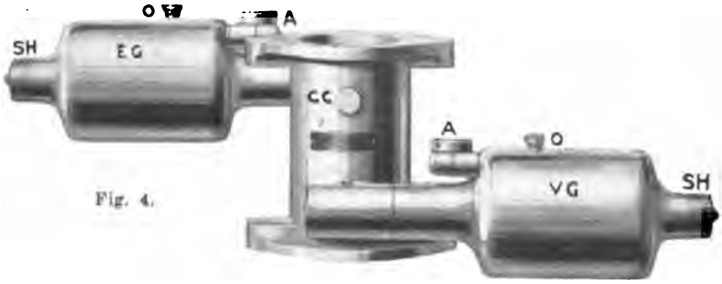


Fig. 4.

Fig. 4—Pierce dual purpose governor. EG—engine governor; VG—vehicle governor; CC—connects between carburetor and inlet manifold; SH—where driving shafts connect; O—oil cups; A—adjusting screws and seals.

CHART NO. 381—Governor for Controlling Vehicle and Engine Speed or Both. Pierce Governor as an Example.

See text page 839 for further explanation.

The Simplex and Duplex Governor.

This governor, fig. 10, is placed between the carburetor and intake manifold. It operates on the centrifugal principle. As the speed increases, the weights W, cause the valve (T), which is of a grid construction, to gradually close the gas passage (GO & G1), thereby cutting off the flow of gas to inlet manifold. Therefore it would be termed a "throttling type governor; centrifugal type."

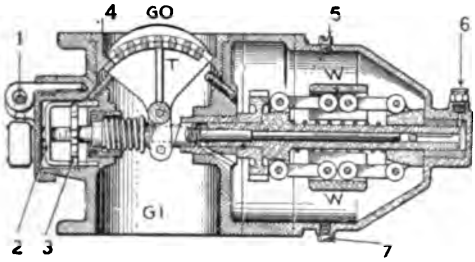


Fig. 10—The Duplex Governor.

1—Locking pin.
2—Yoke.
3—Hand wheel.
4—Valve seat.
5—Oil entrance.
6—Oil cap.
7—Oil discharge.

On the Simplex single drive governor, the shaft is attached to engine or vehicle as may be desired.

On the Duplex double drive governor, one shaft is attached to the engine and the other is attached to the vehicle, at the wheel or transmission.

The difference between Duplex and Simplex is that with the former you can control both the engine and vehicle speeds, whereas with the latter, either the engine or vehicle speeds can be controlled.

On high gear a truck running at 12 m. p. h., the engine may only turn over at 900 r. p. m., but for low gear service the engine may be governed for 1400 r. p. m. Therefore, you would be able to maintain 12 m. p. h. even in second gear.

The governor is a telltale on carburetion If it surges it may result from one of five causes: The mixture is too rich; governor lubrication is bad; the ignition is faulty; the governor valve is dirty; or the cable drive is not steady and free from backlash.

To Set the Simplex or Duplex Governor.

First get the consent of the factory, otherwise you may lose your guarantee. Turn the hand wheel (3) out for higher, and in for lower, speeds. Do not fail to lock the hand wheel with the yoke (2) after setting, if a locking spring is not provided, and see that the yoke does not bind on hand wheel. The locking pin and seal (1) are for the protection of the governor and the engine. Do not touch the valve screws (4).

To operate engine with a governor, for best economy; run vehicle on governor speed as much as possible. Bring vehicle speed up to set maximum governor speed with throttle lever and then advance spark and throttle to the best normal running positions.

Don't over advance throttle, as engine might "hunt" with heavy load on low piston speed. Find the best throttle position and mark it.

Care of Simplex and Duplex Governor.

Lubricate weekly at (5) by filling chamber with medium cylinder oil, 600-W preferred for summer, and in winter add equal amount of light machine oil. Every 1000 miles remove drain (7), fill half full of light machine oil, run for 10 minutes to clean interior and drain out. Then refill as above.

To clean governor valve—if necessary, pour kerosene into air inlet of carburetor while engine is running, varying the speed.

†Make of Governor Used on Different Trucks.

Pierce: Atterbury, Beck, Bessemer, Corbitt, Diamond T, Dorriss, Larabee, Lippard-Stewart, Mascar, Palmer Taylor, Tiffin, Sanford, U. S., Wilcox, King, Kissel, Kleiber, Lambert, Lane.

Monarch: Buckaway, Chase, Columbia, Diamond T, model R, Fargo, G. M. C., Horner, Nelson and Lemoon.

Duplex: Winther, Gary model K, Hall, Schacht, Harvey, Nash, Old Reliable.

Simplex: Acme, Bourne, Dort, Denby, Federal, Gary, Garford, Lamson, Nash.

The Monarch Governor

differs from the Pierce and Simplex, in that **the speed of the ingoing gas is utilized as the motive power for operating the disc** or control member (A)—see page 842.

There are no connections to any moving parts of the engine or vehicle. Neither are there revolving parts as centrifugal weights or balls.

Location of governor is between the carburetor and the inlet pipe. When installing, the adjustment is made when a change in the maximum speed of engine is desired. See page 842 for construction and operation and adjustment. The manufacturers are Monarch Governor Co., Detroit, Mich.

Operation.

When the engine is started and the throttle is in wide-open position the speed of the gases lifts the disc "A" in the tapered chamber "B" to a position the height of which is determined by the amount of spring tension, and it is held in that position by the speed of the gases while the engine is running, and so the throttle "F" is held in a corresponding position, limiting the supply of gas.

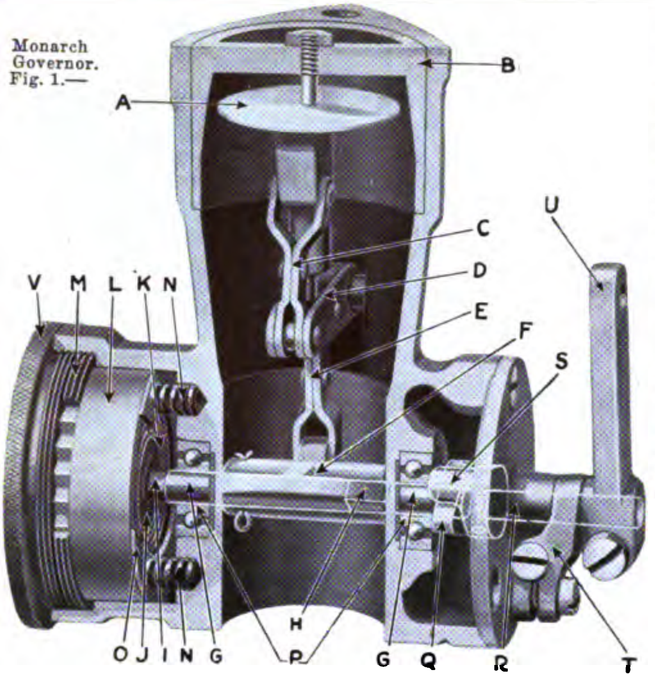
Anything which tends to decrease the speed of the engine, namely, going up hill, through a mud-hole or additional load added, in turn causes a decrease in the speed of the engine and a consequent decrease in the speed of the gases, when immediately the disc drops and opens the throttle to admit a sufficient amount of gas to maintain the speed at which the adjustment was made

—continued on page 842.

---

*Pierce Engine Governor Co., Anderson, Ind. **Duplex Engine Governor Co., 36 Flatbush Ave., Extension, Brooklyn, N. Y. †List not complete.

Monarch Governor. Fig. 1.—



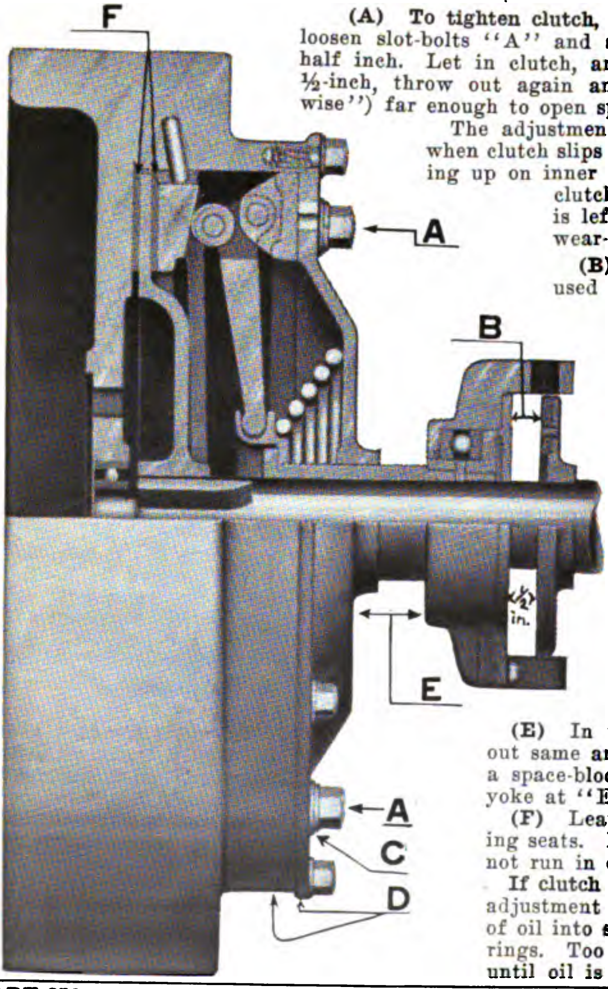
—continued from page 841.

before the additional load was added. The same is also true when the engine is instantly relieved of its load; the speed of the gases increases and raises the disc to the position required to maintain its fixed maximum. It is therefore evident that, an adjustment of spring tension made to produce a certain engine speed, that speed will be maintained regardless of load.

Adjustment.

To adjust the governor to produce any required engine speed, remove the lock and lock pin, unscrew the cover "V," push in on the finger boss on the spring housing "L," and turn in the direction indicated by the arrows "Fast" and "Slow" to increase or decrease the speed, always being sure that the control lever is in a wide-open position when the adjustment is made; and be sure that the cover "V," the lock pin and lock are in place before the truck is put in service.

Adjustment of the Borg and Beck Clutch—See also Pages 42, 668.



(A) To tighten clutch, first "release" with foot lever, then loosen slot-bolts "A" and shift same "clockwise," about one-half inch. Let in clutch, and, if opening at "B" is less than ½-inch, throw out again and tap slot-bolts back ("anti-clockwise") far enough to open space at "B" to full ½-inch.

The adjustment "A" also adjusts foot pedal, and when clutch slips it is usually due to clutch pedal hanging up on inner side of foot board. When adjusting clutch see that at least ½-inch clearance is left between pedal and foot board, for wear-in.

(B) The adjustment at "A" must be used to **increase or decrease** this "B" space. When clutch is "in," if space between these brake faces is less than ½-inch, the throw-out movement will be too short for clean release.

(C) If bolts "A" adjust against last end of cover-slots, screw them out of their mounting-holes and set them back into repeat holes exposed near first end of slots, thus doubling the range of adjustment.

(D) **If, for any reason, the clutch is to be taken apart,** first punch remounting "line-up" marks on cover and casing, as clutch will not work properly if cover is shifted in remounting.

(E) In taking the clutch apart, first throw out same and "lock-out" the spring by placing a space-block between the cover and throw-out yoke at "E."

(F) Leave asbestos rings loose in their working seats. Do not fasten to the metal parts. Do not run in oil.

If clutch **does not work smoothly take out** one adjustment screw and squirt about three spoons of oil into same, just enough to moisten friction rings. Too much oil will cause clutch to slip until oil is burned out.

CHART NO. 382—Monarch Governor. Borg and Beck Clutch.

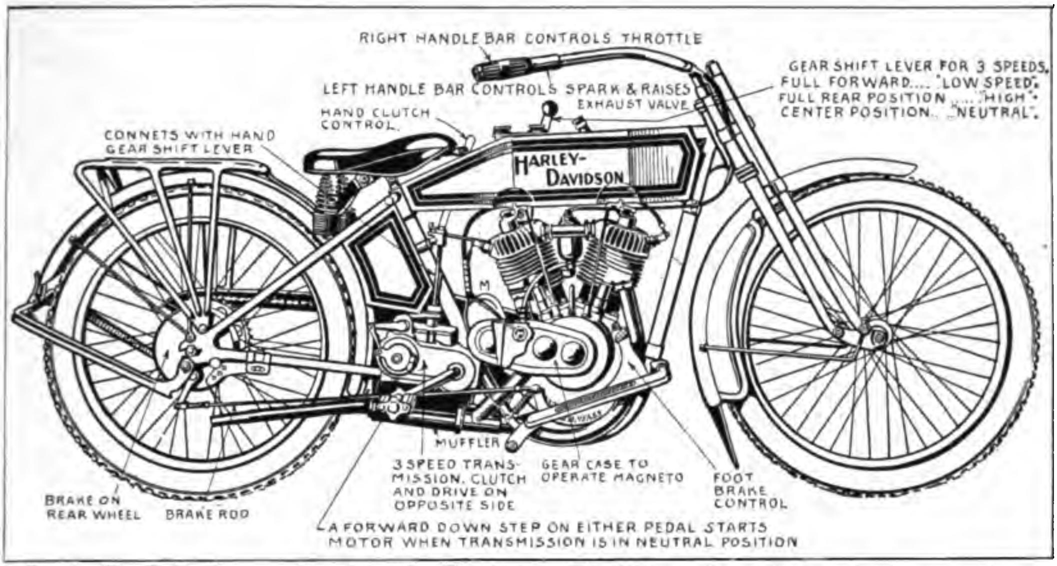

RIGHT HANDLE BAR CONTROLS THROTTLE
LEFT HANDLE BAR CONTROLS SPARK & RAISES EXHAUST VALVE
HAND CLUTCH CONTROL
CONNETS WITH HAND GEAR SHIFT LEVER
GEAR SHIFT LEVER FOR 3 SPEEDS. FULL FORWARD.... "LOW SPEED". FULL REAR POSITION ..... "HIGH". CENTER POSITION.. "NEUTRAL".
HARLEY-DAVIDSON
M
MUFFLER
3 SPEED TRANSMISSION. CLUTCH AND DRIVE ON OPPOSITE SIDE
GEAR CASE TO OPERATE MAGNETO
FOOT BRAKE CONTROL
BRAKE ON REAR WHEEL
BRAKE ROD
A FORWARD DOWN STEP ON EITHER PEDAL STARTS MOTOR WHEN TRANSMISSION IS IN NEUTRAL POSITION

Fig. 2—The H. D. three-speed, model 11F. The 1918 model 18F is similar. The gear box is mounted to the rear of engine on the frame. Note lettering on illustration.

To start the three speed model engine, shift gears into "neutral" position and have clutch "in;" start engine by pedal. After engine is started release clutch. To start machine place gears in mesh, starting off on "low," gradually applying clutch. The Remy electric system below, is used on this type of machine and is then called model 18J.

The Remy Lighting, Generating and Ignition System.

The generator is driven by the engine. The shaft being connected to engine. **The armature of generator is a drum wound type mounted in the upper portion of the generator. Current is "direct."**

The generator is connected with a 6 volt storage battery as shown in fig. 6. The generator supplies current for lamps, horn and ignition, the surplus current being stored by the battery. The battery then supplies current to the lamps when the engine is not running.

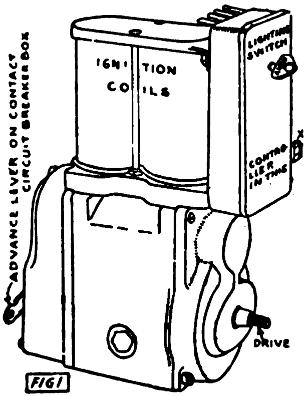


FIG1

Fig. 1—The electric generator with ignition breaker box, vacuum controller and ignition coils all in one unit.

The lighting switch has three positions; off, bright head and tail lights, dim head and tail lights.

The ignition (direct current) is taken from battery to start on and generator, after generator is running. The current is carried through a circuit breaker on lower end of the generator. This circuit breaker is similar to a magneto circuit breaker and has a lever for advancing.

The current is carried to coils of high tension type without vibrators, mounted directly over generator. This low tension current, which is 6 volts, is interrupted at the proper time being transformed into high tension current through the secondary windings of coils. A distributor carries the current to the spark plugs.

***Vacuum controller is located in the switch case and is connected through a check valve (X, fig. 8) to the engine intake manifold by a small pipe. When the engine is turned a fraction of a revolution for starting, either by the step starter or by pedaling, a vacuum is created in the intake manifold which in turn acts upon the controller, drawing the contacts (C, A, fig. 8) together, and thus connecting the generator, horn and ignition to the battery and holding this circuit closed until after the engine has stopped running for a few seconds. The purpose of this device is to automatically cut off the connection between battery and generator.**

In reality it is a "cut-out" for the purpose explained on page 384. A separate switch for ignition is not necessary as the ignition current is taken from battery to start on.

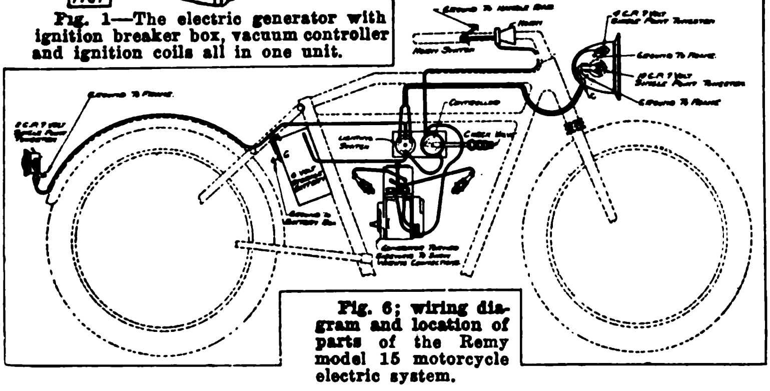


Fig. 6; wiring diagram and location of parts of the Remy model 15 motorcycle electric system.

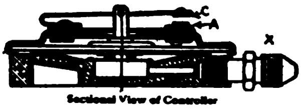


Fig. 8 — Sectional view of controller.

CHART NO. 383—The Harley Davidson Motorcycle. Remy Motorcycle Electric System.

Note: The 1915 Harley-Davidson used the vacuum cut-out, explained here as a matter of information. Later models used the mechanical governor principle of disconnecting and connecting the battery, similar to the mechanical cut-out explained on page 811. Model 18-E is a direct geared (no transmission); 18-F, has 3 speeds and uses a magneto (Dixie or Berling) for ignition, no electric system; 18-J—has 3 speeds and uses electric system with coil and battery ignition. See insert No. 3 for H.-D. engine.

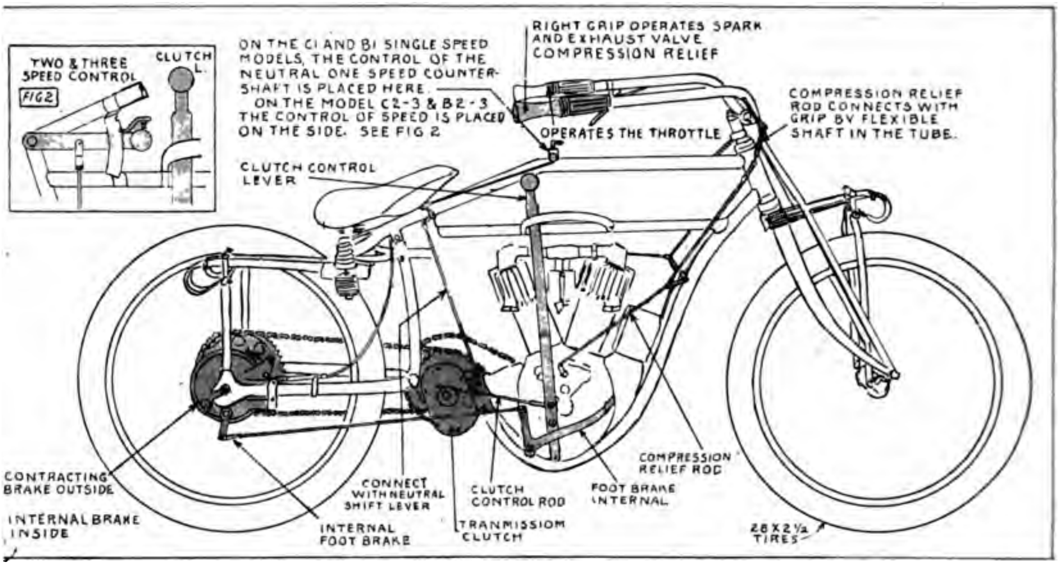

TWO & THREE SPEED CONTROL
FIG 2
CLUTCH L.
ON THE C1 AND B1 SINGLE SPEED MODELS, THE CONTROL OF THE NEUTRAL ONE SPEED COUNTER-SHAFT IS PLACED HERE.
ON THE MODEL C2-3 & B2-3 THE CONTROL OF SPEED IS PLACED ON THE SIDE. SEE FIG 2
RIGHT GRIP OPERATES SPARK AND EXHAUST VALVE COMPRESSION RELIEF
OPERATES THE THROTTLE
COMPRESSION RELIEF ROD CONNECTS WITH GRIP BY FLEXIBLE SHAFT IN THE TUBE.
CLUTCH CONTROL LEVER
CONTRACTING BRAKE OUTSIDE
INTERNAL BRAKE INSIDE
INTERNAL FOOT BRAKE
CONNECT WITH NEUTRAL SHIFT LEVER
TRANMISSIOM CLUTCH
CLUTCH CONTROL ROD
FOOT BRAKE INTERNAL
COMPRESSION RELIEF ROD
28 X 2½ TIRES

Fig. 1—The Indian Twin type of motorcycle using a neutral counter shaft as described on page 845.

If machine is equipped with this one speed device, called a "neutral counter shaft," its purpose is mainly to promote starting without raising the rear wheel. By shifting the small lever underneath handle bar, the dogs are disengaged and drive to the rear is cut out. The clutch is then engaged and engine started. After engine is started clutch is disengaged until machine is started.

If the three speed gear box is used instead of a single speed—it is mounted in the same location, but a control lever is placed on the side as shown in fig. 2, instead of the small hand lever. When starting with a two or three speed, the gears are shifted to neutral position and the action is just the same as above. Note the name and location of parts as lettered.

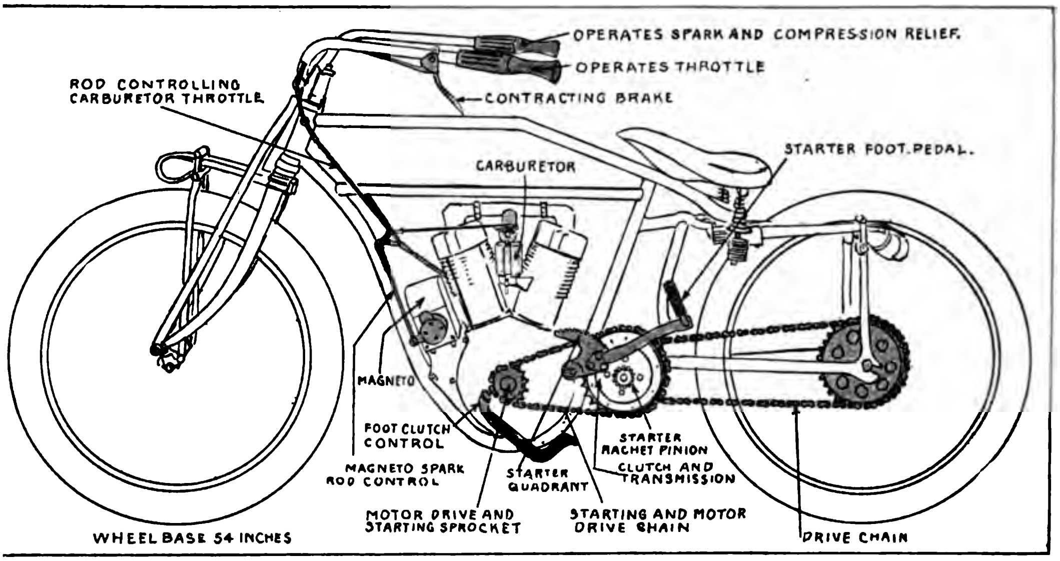


Fig. 2—The Indian starter: The down pressure on the foot lever brings the quadrant into engagement with the pinion on the clutch and turns the engine over three times to each stroke, the clutch being engaged to obtain positive and full crank effect.

This starting of the engine can be done without jacking up the rear wheel, simply by putting the shifting lever into neutral on the three-speed machine and by disengaging the driving cog in the same manner on the single speed model.

When the starting crank is released on the bottom of the stroke it is automatically returned to the starting position by a strong coil spring and when not in use is held in a convenient position by a strong clip. When the starting crank is in normal position it is fully disengaged from the pinion which revolves with the clutch.

The mechanism consists of a quadrant with a reverse motion and meshes with a ratchet pinion on the clutch shaft. The ratio is three turns of the engine to one stroke of the starter, not taking into account the spinning effect and extra momentum gained.

See Chart 385 for description of the Indian three speed gear and index for Indian engine.

CHART NO. 384—The Indian Control and Method of Starting.

gnition on Indian is Dixie high tension magneto. See insert No. 8 and page 811 for "Mag-Dynamo."

Motorcycle Clutch and Transmission—Indian Three-Speed as Example.

Operating plan of three-speed Indian motorcycle: The principle of construction and operation of the three-speed gear are identical with the two-speed, except that there is an extra set of gears for intermediate ratio.

When gears "A" and "B" are locked together by dogs "G," the "high ratio" or "high speed" is coupled up.

When gears "B" and "E" are in mesh, "intermediate" or "second speed" ratio is obtained.

And when gears "B" and "C" are connected through the dogs "H," the "low speed" is obtained.

There are two "neutral" positions in this gear set; between the high and intermediate with the gears as shown in the illustration, and between the intermediate and low, with gear "B" on the other side with "E," with the same relative position.

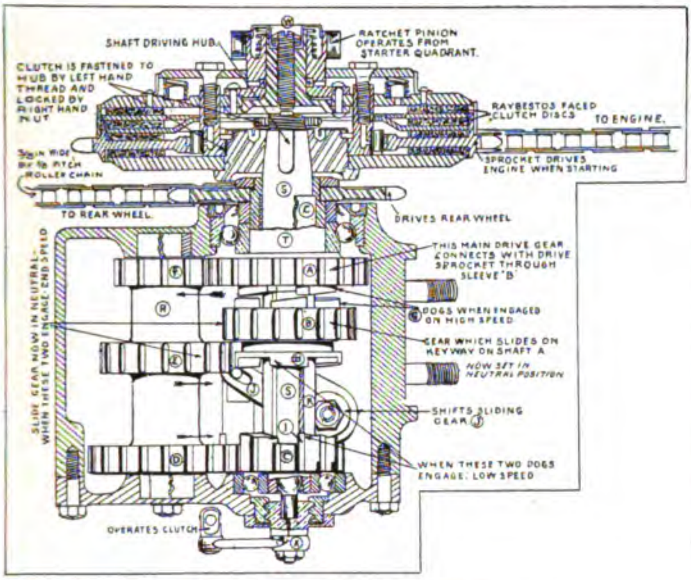

SHAFT DRIVING HUB
RATCHET PINION OPERATES FROM STARTER QUADRANT.
CLUTCH IS FASTENED TO HUB BY LEFT HAND THREAD AND LOCKED BY RIGHT HAND NUT
RAYBESTOS FACED CLUTCH DISCS
TO ENGINE.
5/8 IN WIDE BY 5/8 PITCH ROLLER CHAIN
SPROCKET DRIVES ENGINE WHEN STARTING
TO REAR WHEEL
DRIVES REAR WHEEL
THIS MAIN DRIVE GEAR CONNECTS WITH DRIVE SPROCKET THROUGH SLEEVE "B"
DOGS WHEN ENGAGED ON HIGH SPEED
GEAR WHICH SLIDES ON KEYWAY ON SHAFT A
NOW SET IN NEUTRAL POSITION
SLIDE GEAR NOW IN NEUTRAL—WHEN THESE TWO ENGAGE—END SPEED
SHIFTS SLIDING GEAR J
WHEN THESE TWO DOGS ENGAGE: LOW SPEED
OPERATES CLUTCH
W
S
C
T
F
A
R
B
E
G
S
J
D

Fig. 2. The Indian clutch and 3-speed transmission.

Indian Clutch.

Construction: The Indian clutch is a multiple disc dry plate type. The drive is transmitted through four Raybestos faced discs which engage with four polished steel discs and are held on engagement by eight small springs equal distances apart.

This clutch is applied to the one, two or three speed transmission.

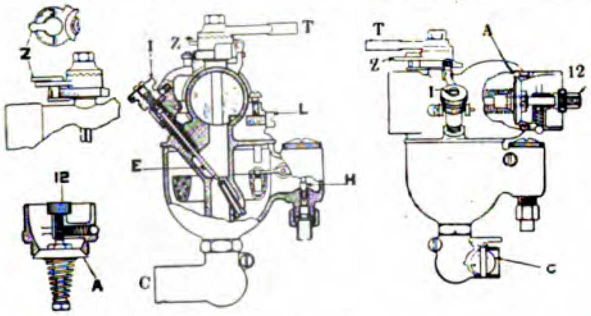
Operation: Lever "X" operates clutch and has about 45° travel. When pulled forward it releases clutch; backward it engages clutch.

It is connected with foot pedal, which has a pull back spring. Pressure on pedal forward, causes the plunger rod (marked by mistake, "shaft driving hub") to come in contact with the screw "W," which under pressure compresses the springs and pulls the whole assembly mounted on the inner plate—outward—thus freeing the driving discs.

When control pedal is released, the pull back spring causes a reverse action through the mechanism and again brings the discs into engagement.

Schebler Motorcycle Carburetor—Used on Indian and Harley Davidson.

Description; model "H," ¾ and 1 in. Compensating type. Variable fuel feed. Supply of gasoline controlled by (Z), which raises the gasoline needle valve (I), which gives an adjustment on low, intermediate and high speeds. C—is air intake and can be turned so warm air can be drawn from engine.



Low speed adjustment: See that the leather air valve "A" seats lightly, but firmly. Then turn knurled button "I" to the right until the needle point "E" sets in spraying nozzle. Now turn "I" to left about two turns and open low speed adjusting screw "L" about three turns, then open throttle about half way to start engine. After starting close the throttle and turn needle valve adjusting screw "I" to the right or left until engine runs smoothly without missing. If with this low speed adjustment, engine runs too fast, turn low speed adjusting screw "L" to the right.

High speed adjustment: Do not make the adjustment with the engine running idle. The machine should be run in high speed on the road. The throttle and spark should be advanced fully. The adjustment is now made by the pointer "Z," which as it moves from "1" toward "3" increases the supply of gasoline. Moving the indicator from "3" toward "1," cuts down the flow of gasoline. When the indicator reaches the right point, the engine will run without missing or backfiring.

Starting—air valve can be locked to assist in starting by pulling out button (12) and giving ¼ turn. When engine starts, release air valve (A) by turning button (12) back.

Extra air port for high speed on the Harley Davidson carburetor is provided inside of mixing chamber to admit more air at extreme high speed.

To set float level—place float 1$\frac{9}{32}$" from top of bowl to top of cork float. The arm can be raised or lowered to meet these conditions.

CHART NO. 385—Motorcycle Transmission; Indian Three-Speed as an Example. Schebler Motor cycle Carburetor.

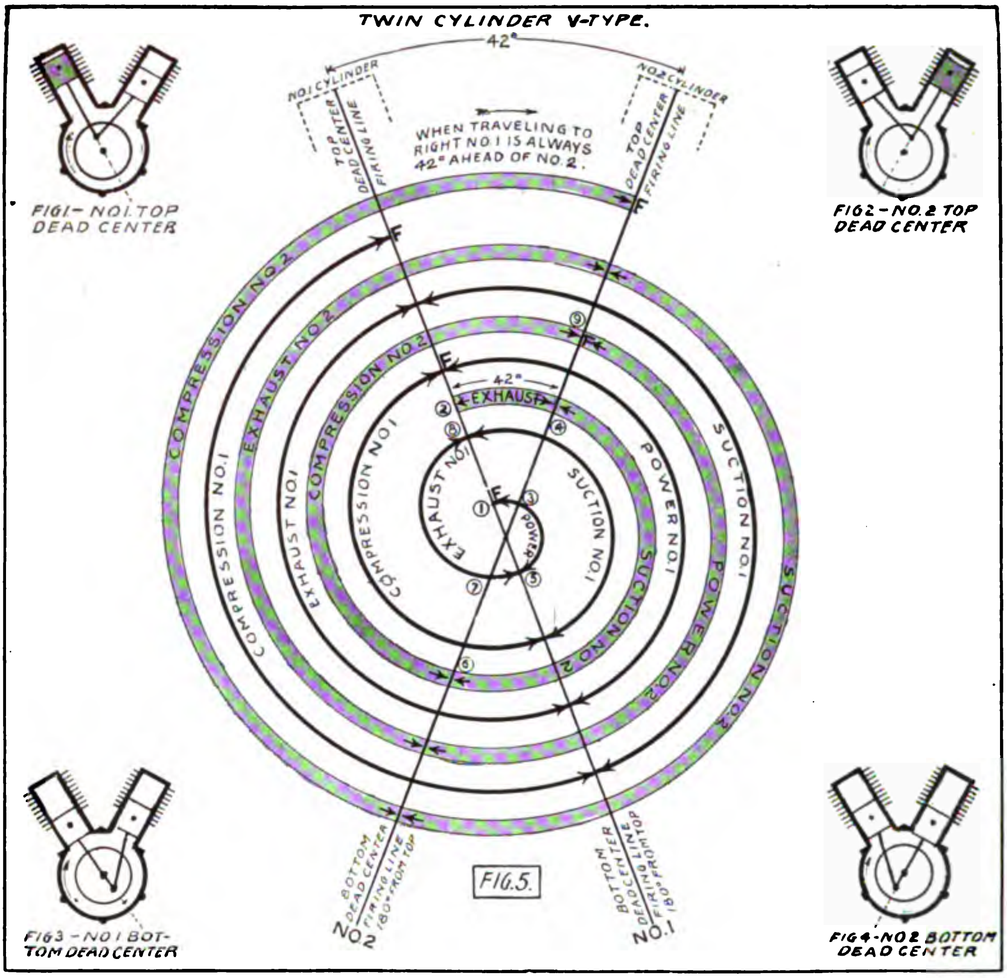


Fig. 1 illustrates two cylinders placed 42° apart. We will call cylinder to the left No. 1 and cylinder to the right No. 2. Bottom of connecting rods are together on one crank pin.

Note No. 1 piston is on top of its stroke and connecting rod is straight up and down, in line with the crank pin; in other words on its "firing center." (If it is on top of compression stroke, which we assume it is.) Piston No. 2, is not on top of its stroke; its connecting rod where attached to crank pin is 42° away from its firing center. No. 2 has 42° yet to travel to complete its exhaust stroke (see 2 to 4, fig. 5).

Fig. 2; No. 1 has fired and traveled 42° on its power stroke (see 1 to 3, fig. 5). No. 2 piston is now on top of its suction stroke (4) and on its dead center firing line.

Fig. 3; No. 1 has reached bottom of its firing or power stroke (see 5, fig. 5), having traveled 180° or half a revolution. No. 2 is not quite down in its suction stroke, being 42° behind No. 1.

Fig. 4; No. 2 has now reached bottom of stroke on suction, having traveled 180°, whereas No. 1 is part the way up on its exhaust stroke.

Therefore, starting with firing of No. 1 at 1F; if No. 1 makes a complete revolution; one stroke down on power stroke and one stroke up on exhaust, from 1 to 8—it will have traveled 360°. No. 2, however, will lack 42° of completing its revolution, and will have to travel 42° more than 360° to complete its revolution from 2 to 9.

Therefore when No. 1 travels 360°, No. 2 must travel 360 + 42 or 402° before it fires. Or No. 1 will fire again, 318° after No. 2 fires.

Fig. 5; black line shows travel of No. 1 and shaded line of No. 2. The firing lines of each, or top and bottom center are lettered on illustration.

Start with No. 1 firing at (F) and follow the stroke to bottom or a half revolution; for instance, from 1 to 5 on No. 1, and 4 to 6 on No. 2; each represent a stroke or half revolution or 180°.

From 1 to 8 on No. 1, represents a revolution or 360°.

From 2 to 9 represents 42° more than a revolution on No. 2. From 4 to 9 would represent a revolution on No. 2.

While observing the travel of No. 1, at the same time follow No. 2 and note what it is doing. For instance, when No. 1 is traveling from 1 to 3 on its firing or power stroke; No. 2 is traveling from 2 to 4 on its exhaust stroke, having 42° of its exhaust stroke to complete before it is on its dead center, when it starts on its suction stroke.

HART NO. 386—Firing Order of a "V" Type Twin Cylinder Engine; cylinders 42° apart and oth connecting rods on one crank pin. (See Chart 45, page 93 and study meaning of degrees.)

ee insert No. 3 for Dixie motorcycle magneto and page 811.

How To Repair Tops.

Any repair shop, by the investment of a small amount of money in equipment, and the exertion of reasonable care, can develop a profitable top repair department. It is as an essential part of the trade as is the machine shop or the vulcanizing shop.

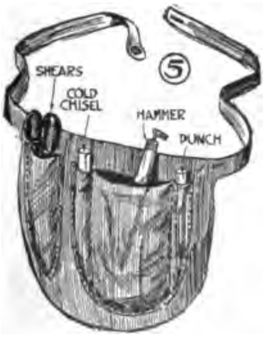
Only a small amount of equipment is necessary in a top repairshop, and this, with the exception of the sewing machines, may be made by the repairman himself.

The top building frame is shown in fig. 2, and it is only used when the car for which the top is being repaired cannot be left during the work. It is simply an adjustable framework upon which the top may be placed in exactly the position it occupies when up, and on the car. For each car the frame is set to duplicate the measurements of the top supporting irons and the car body. Then the workman can repair or rebuild the top with assurance that it will fit when returned to the car. **When possible, the top should be left on the car during the repair.**

In order to render all parts of the top accessible, when left on the car, a framework shown in fig. 3 is set up around three sides of the car. This framework is about 18 in. high, and comprises three planks resting on four small wooden horses. **Another method of accomplishing the same result,** yet one which the author has never seen, would be to construct a pit below the floor level. This would permit the workman to work directly from the floor and save the time lost in stepping to and from the platform.

All work is laid out and cut on the laying out table shown in fig. 4. This table is about 6 ft. wide, 12 ft. long and 28 in. high. A notched rack at one end supports the rolls of top material and enables the workman to readily obtain or replace the top material when desired. Rolls may be easily removed from the frame, or as many as three rolls of material may be carried at one time.

The tools of the workman are few, comprising a light cross pene **hammer,** with a tack puller fitted to the end of the handle; a heavy pair of **shears,** a small **cold chisel** and a **nail set** or **punch.** These are carried in a special apron, made of top material, as shown in fig. 5. In addition, a **carpenter's square,** a 10-ft. **straight edge,** a **yard stick** and a **plumb bob** are required. The plumb bob is used to plumb up the edges of the back curtain, when fitting, to make certain that they are hung straight.



In addition, several special punches and dies will be necessary for cutting the openings for the curtain fasteners. One of these—styled the **Murphy die**—is shown in fig. 7, and corresponding dies are used for each type of fastener.

The sewing machine used in this work is of extra heavy construction, and is similar to those used by harness makers. These machines should be motor-driven, and may be purchased from almost any reliable sewing machine manufacturer.

So much for the equipment—now for the method of doing the work. Briefly this consists of removing the top material, part by part, using the parts as patterns to cut the new parts by; fitting the parts to the top frame; removing the parts; sewing them together, and then placing them again on the frame. Careful work is essential, and after carefulness has become a habit speed may be developed. Carefulness, then speed, are the only two requirements for a successful top repairman.

The following is a typical example of the method used in re-covering an automobile top. Though it specifically applies to a Ford top, in general, it may be applied to any car.

1—**Remove the top covering from the frame,** part by part, using the hammer and cold chisel as tools. Note how each part is fastened, as the rebuilding must be exactly the reverse of the tearing down.

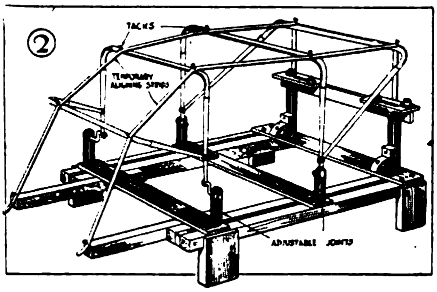
2—**Using each part as a pattern, one by one, mark out the new parts on the top material.** Care must be taken to allow extra material at the edges for fastening the material to the frame. The method of constructing the rear quarter is shown in fig. 10, and this method applies in general to each of the top parts.

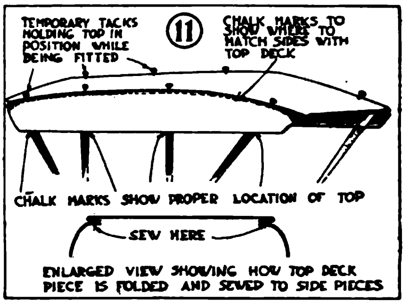
All metal fastener holes should be punched, using the holes in the old parts as guides, and all square corners should be checked up by means of the square. **The parts are then sent to the machine,** and the necessary sewing done. The **celluloid windows** are also placed in the rear curtain at this time.

In the meantime the top frame should be placed in good condition. If any bows are broken new bows should be fitted. Ordinarily new wrapping should be tacked around the bows, but if this wrapping is only faded, it may be dyed to conform to the inside of the top material.

3—**The side pad covers should now be made,** according to the pattern shown in fig. 8. On the Ford black cambric is used, but in every case the material should conform in color and quality to that used in the top material.

Dr. S. A. Peake's method of vulcanizing small holes, large as ½ inch in tops is as follows: First clean both sides of surface with gasoline, then use "Mastic" or "Tire-Doh" and work it to a point and insert in hole, filling hole. Cut off on each side. Then place a hot sad iron underneath and on top. This will vulcanize the Mastic in the hole.




⑪
TEMPORARY TACKS HOLDING TOP IN POSITION WHILE BEING FITTED
CHALK MARKS TO SHOW WHERE TO MATCH SIDES WITH TOP DECK
CHALK MARKS SHOW PROPER LOCATION OF TOP
SEW HERE
ENLARGED VIEW SHOWING HOW TOP DECK PIECE IS FOLDED AND SEWED TO SIDE PIECES

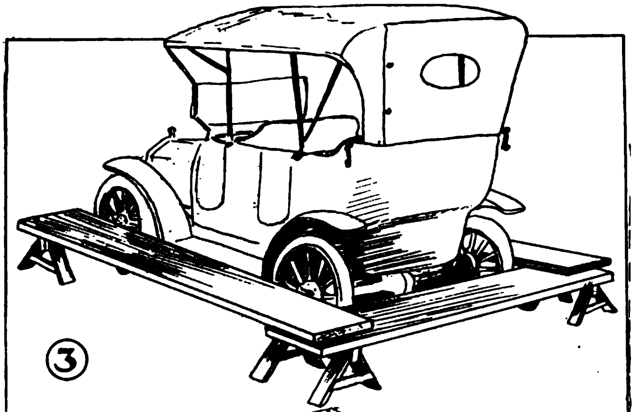


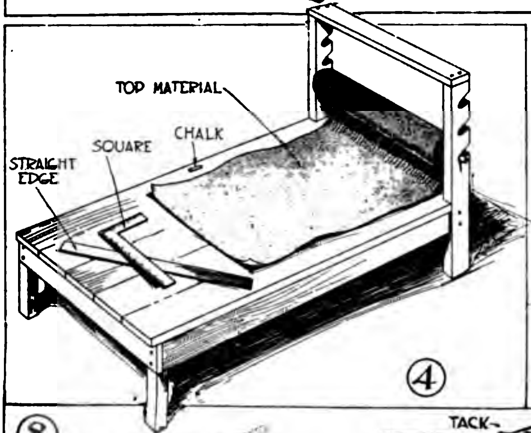
Fig. 2: When the car cannot be left in the shop, this adjustable frame enables the mechanic to duplicate the method of holding used on the car.

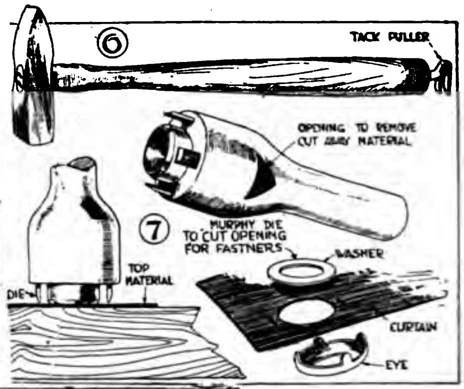
Fig. 3: Most tops are repaired right on the car, and a framework on three sides of the car renders all parts accessible.

Fig. 4: The rolls of top material are carried on rods hung in a notched upright, and the material is marked out and cut to form on the laying out table.

Fig. 6: The other end of the hammer handle is fitted with a tack puller, thus combining the two tools.

Fig. 7: Special dies are required to cut the openings for the fasteners. This is a most common type.




⑥
TACK PULLER
OPENING TO REMOVE CUT AWAY MATERIAL
⑦
MURPHY DIE TO CUT OPENING FOR FASTNERS
WASHER
TOP MATERIAL
DIE
CURTAIN
EYE

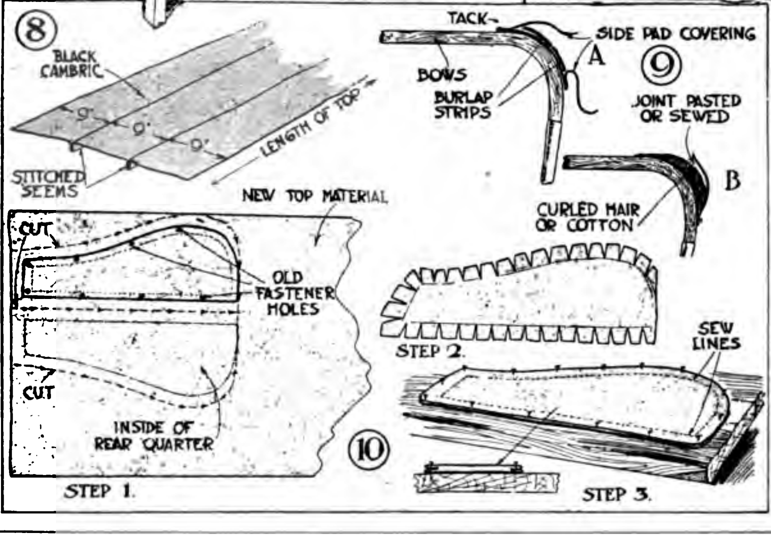


Fig. 8: The side pads are a single strip of cambric 29 in. wide, and sewed as shown.

Fig. 9: This is the method of building up the side pads.

Fig. 10: This shows the various steps in laying out and cutting a rear quarter. It is then taken to the machine and sewed.

Fig. 11: After all parts of the top are made, they are temporarily tacked to the bows and fitted. When a perfect fit is secured, the edges are marked, and the parts removed and sewed. They may then be replaced on the frame and permanently fastened in place.

CHART NO. 387—How to Repair a Top.

From Motor World, by S. Thorton Williams.) Note—The shop layout and special tools, together with the procedure, were obtained from the Barton Auto Top Co., Detroit.

4—Line up the top bows. The method of doing this is shown in fig. 2. Heavy canvas straps are passed over each side of the bows, drawn tight, and tacked in place. The front bow should fit down over the windshield; the two middle bows should be vertical, and the position of the rear bow can be gauged by the length of the straps holding it down to the body back.

5—The side pad liners are next tacked in place, and the burlap strips tacked tightly in place. After this the curled hair, or cotton packing, is replaced, and the side pad flaps pasted into place. If desired, the edges of the pad may be sewed together. The above operations are shown in detail in fig. 9.

6—The rear quarters and back curtain are now fitted and tacked in place, after the metal fasteners have been applied, as shown in fig. 7. All vertical edges are plumbed up with a plumb bob, as any edge out of the vertical here is particularly noticeable.

7—The two side quarters are now temporarily tacked in place, beginning at the front and working to the back. These quarters should be drawn tight, without wrinkling. The edges of the deck are then turned under, and the deck is temporarily tacked in place.

8—By carefully fitting and changing, the top may be fitted to the bows in exactly the position it is to occupy. When everything appears to fit correctly the side curtains should be placed in position, and if necessary, the tacks should be removed and the top pieces shifted until the side curtains fit. (In most cases new side curtains do not have to be made; but if so, the new curtains should be fitted at this point.)

When everything is right the mating edges of the top pieces should be marked with chalk, and these marks crossmarked, as shown in fig. 11. Then by joining the corresponding marks together, the sewing machine operator can sew the parts together correctly. Chalk marks should also be placed at the points the edge of the top crosses the bows. This permits the top to be correctly replaced after a sewing.

10—The parts of the top are then removed, and the flaps on the edges that are to be, sewed trimmed down to a width of about 2 in. The parts are then sent to the machine and sewed together.

11—To complete the work it is only necessary to replace the top covering and tack it securely in place. All extending edges are removed and the joints covered by a narrow strip of cloth material fastened by black upholstering tacks.

The above covers the method of completely replacing the top covering, with the exception of the side curtains. As stated, this is rarely necessary, as the side curtains are little used. If desired, any one part of the top may be replaced with new material, providing the other parts are in good condition. However, if either the deck or side quarters must be replaced, it is necessary to tear the top completely down in order to sew it together again.

In cases where it is necessary to replace some parts of the top covering, it will usually be found advisable to renovate the interior and exterior of the balance of the covering to make it conform to the appearance of the new part. Or this renovating may be done at any time to improve the appearance of the top.

After applying any patches that are necessary; replacing broken windows, and tacking on new binding at the edges where required, the top should be thoroughly brushed and cleaned. Gasoline should never be used for this purpose if rubber is used in the top material construction, as its action is to destroy the rubber. Soap, warm water and a brush are all that are usually required.

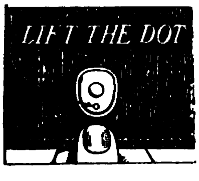
When the top is thoroughly cleaned and dried top dressing may be applied to outer surfaces, and the faded inner surfaces may be dyed black. There are many brands of top dressing on the market for this purpose, and any well-known brand should prove entirely satisfactory. By exercising a little care, the appearance of a shabby top may be greatly improved by this simple cleaning, patching up loose ends and application of top dressing.

Where to Obtain Top Material.

Tools; such as eyelet punches and dies for sockets and eyelets, special hand screw drivers, curtain fasteners, etc.: Carr Fastener Co., Cambridge, Mass. G. W. Murphy Co., Amesbury, Mass.

Top material; Cray Bros., Cleveland. O.; Du Pont Fabrikoid Co., Wilmington, Del.; F. S. Carr, Boston, Mass.; L. C. Chase Co., Boston. & Chicago; Pantasote Co., 11 Broadway, New York.

Top and upholstering dressing and celluloid for curtain lights etc.: Arsenal Varnish Co., Rock Island, Ill.; Cray Bros., Cleveland, Ohio; F. S. Carr, Boston, Mass.



Lift the dot fastener is a very popular curtain fastener. To unlock and remove, lift dotted end of socket which is placed nearest edge of curtain. It is natural to lift the edge of the curtain so there should be no difficulty in remembering to always "lift-the-dot" and avoid tearing the curtains. Mnfgd. by Carr Fastener Co., 31 Ames St., Cambridge, Mass.

Rain shields similar to illustration fig. 6, page 732, for placing over the wind shield to prevent snow and rain accumulating is another profitable accessory to handle—mnfgd. by Jos. N. Smith Co., Detroit, Mich.

Seat covers are profitable to handle. Cray Bros., Cleveland, O.; Glover Eq. Co., Indianapolis, Ind.

Top and upholstering dyes and dressing—Cray Bros., Cleveland, O.

Complete Tops—Cray Bros., Cleveland, O.

Glass curtain lights are becoming very popular. They are rather expensive however but add considerably to appearance of a car. The glass is beveled and comes with frame ready to place in curtain. The Borbein Auto Co., 2109 No. 9th St., St. Louis, Mo. will supply this—also top material, etc. in small quantities.

Supplement
ON THE
PACKARD
TWIN SIX-"3-25" and "3-35"

Packard Operation.

Preliminary to starting; put gear shift lever in neutral (see page 498 for location of parts). Set hand brake. Set spark lever in mid position (see page 858). Be sure air gauge shows pressure in tank—if not, use hand air pump on instrument board (page 498). Open throttle about one-sixth.

Adjust air valve control, which is to the right of gasoline gauge (see page 855). Cold weather pull all way out to "choke." Warm weather this will not be necessary.

To start engine: turn ignition switch to "ignition." Crank engine, using electric starter.

After engine starts; push air valve adjustment in and set at best running position. Close throttle until engine runs slowly—a finer adjustment can be obtained by setting the mixture control with the throttle closed.

To start car; usual procedure. See pages 486, 488. The movement of gear shift lever is shown on page 498.

Standard Adjustments.

Ignition interrupter points should be set .015 to .020 inch when fully separated.

Ignition timing: The spark setting in the fully advanced position should be 2⅝ inch (measured on the circumference of the fly wheel) before upper dead center.

Should it become necessary to check this, proceed as follows: Remove motor starter switch cover over fly-wheel. Set the spark lever on the steering wheel in the fully advanced position. Open all priming cups with the exception of the one in No. 1 cylinder in the right block. Crank the engine by hand until compression begins in this cylinder, then open this priming cup and continue to crank the engine slowly to the point where the right interrupter points just begins to separate. In this position, the letters "S. R." on the fly-wheel should be just opposite the center line of the engine, as indicated on the crank case.

In order to test the synchronism of the left hand block, proceed as above excepting that the priming cup in No. 1 cylinder in the left block should be closed. Under these conditions, the letters "S. L." should be just opposite the center line of the engine as above.

Spark plug points should be separated .032".

The auxiliary air valve should have 5/32 inch drop when the control on the instrument board is set for the best idling position. To check, proceed as follows:

Set the auxiliary air valve control for the best idling position. In this position groove No. 4 is flush with the end of instrument board bracket.

Measure height of top of air valve stem from some fixed point on the engine. Depress air valve until it strikes inside spring. Measure height of top of stem as before. The difference in these two measurements is the air valve drop.

Make sure that air adjusting connecting rod clevis is so adjusted that the air shutter completely closes when the control on the instrument board is pulled out. See also page 854.

Clutch brake: Adjustments for wear can be made by loosening the nut on the stud which projects through the slot in the clutch cover and by sliding the whole assembly toward the rear.

Before tightening the nut, be sure that the brake facing does not make contact with the clutch brake disc when the clutch is engaged.

The amount of clearance should be governed by the speed of shift desired.

The standard setting allows ⅛ inch to 5/32 inch compression of spring with the clutch completely disengaged.

To adjust the foot (external) brakes properly, make the clearance between the band and the drum 1/32 inch and equal all around. In making this adjustment proceed as follows:

Adjust the nut on the rear support until the clearance between the drum and the brake band is 1/32 inch at this point.

Adjust the two nuts on the shank of the clevis just below the eye bolt at the front of the brake until the distance between the lower half of the brake band and the drum is 1/32 inch.

Adjust the T handle, which operates the adjusting screw, until there is a clearance of 1/32 inch between the upper half of brake band and drum.

The hand (internal) brakes should be evenly adjusted so that when applied there is the same resistance on each rear wheel. The following adjustments are to be made:

Make all adjustments for wear on the side pull rods connected to the cam shaft levers.

By removing the rear wheel the hand brake band can be set concentric with the brake drum by means of the adjusting set screw at the rear. The band should just clear the drum at this point.

Hand lever should be in the sixth notch from the front when brakes are applied.

Adjust accelerator pedal to have a clearance of 5/16 inch between pedal and top of floor board when throttle is wide open.

The oil pressure should be 20 to 25 pounds at 1000 revolutions per minute; corresponding to a speed of approximately twenty-five miles per hour; with the engine hot. A lower pressure when the supply is up to level indicates that the oil being used has low viscosity or that the relief valve opens too far.

To adjust the relief valve opening, change tension of relief valve spring located in pump housing—see page 859.

Compression in the cylinders should show 75 pounds plus or minus 3 pounds pressure with engine cold and at cranking speed, with all cylinder petcocks closed and the throttle wide open.—(see also page 853.)

Gasoline pressure: gauge on instrument board should show 1½ to 2½ pounds pressure.

The pressure may be increased by removing the plug at the top of the pressure pump cylinder and unscrewing the smaller plug at its base. To decrease pressure, screw in the plug.

Valve clearance: Inlet and exhaust valves should have .004-inch clearance between valve stem and roller holder set screw when engine is cold. Be sure that valve is fully seated when measuring clearance.

The vibration damper on the front end of the crank-shaft should be adjusted to slip under a pull of approximately 140 lbs.

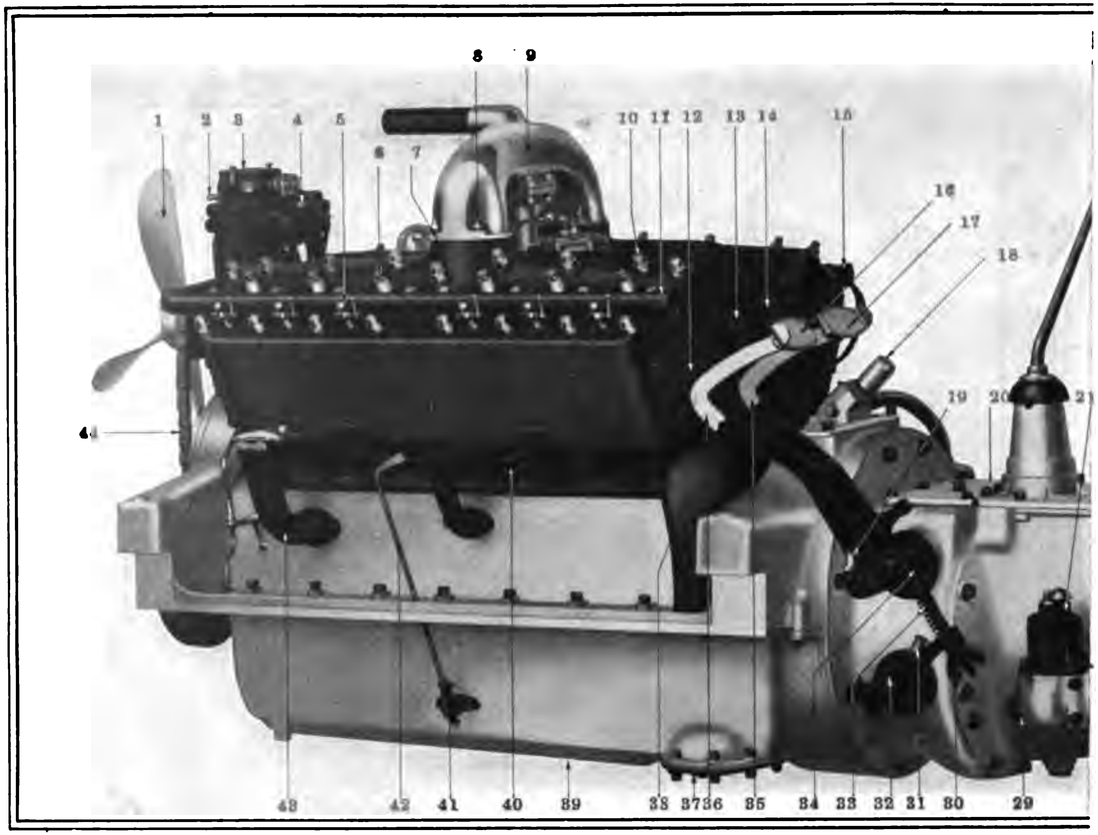
Clutch pedal: When the clutch is in the fully engaged position, the pedal should depress 1¼ inch under light spring pressure before resistance of the heavy clutch spring is encountered.

If the pedal is brought against the floor board before the clutch is entirely engaged, full action of the clutch spring is not obtained which will cause the clutch to slip.

The rod connecting the clutch pedal with the clutch release lever on the left of the clutch housing gives the necessary means for obtaining the correct adjustment for the clutch pedal. Lengthening the rod by means of the thumb screw will increase the amount of travel under light pressure before disengaging clutch.

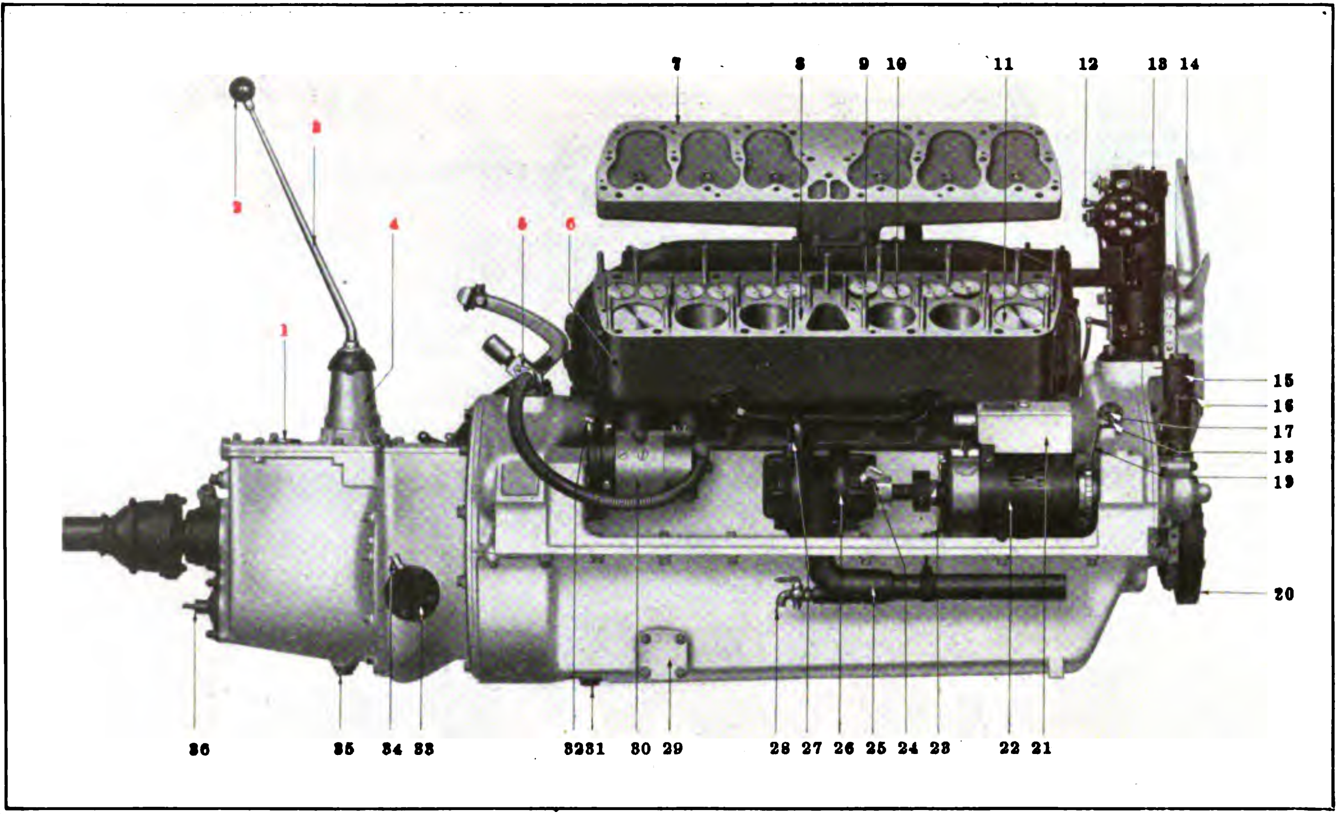
No other change from the original adjustment will be required as clutch surfaces are automatic in their compensation for wear.

Front wheels should "toe-in" ⅜".



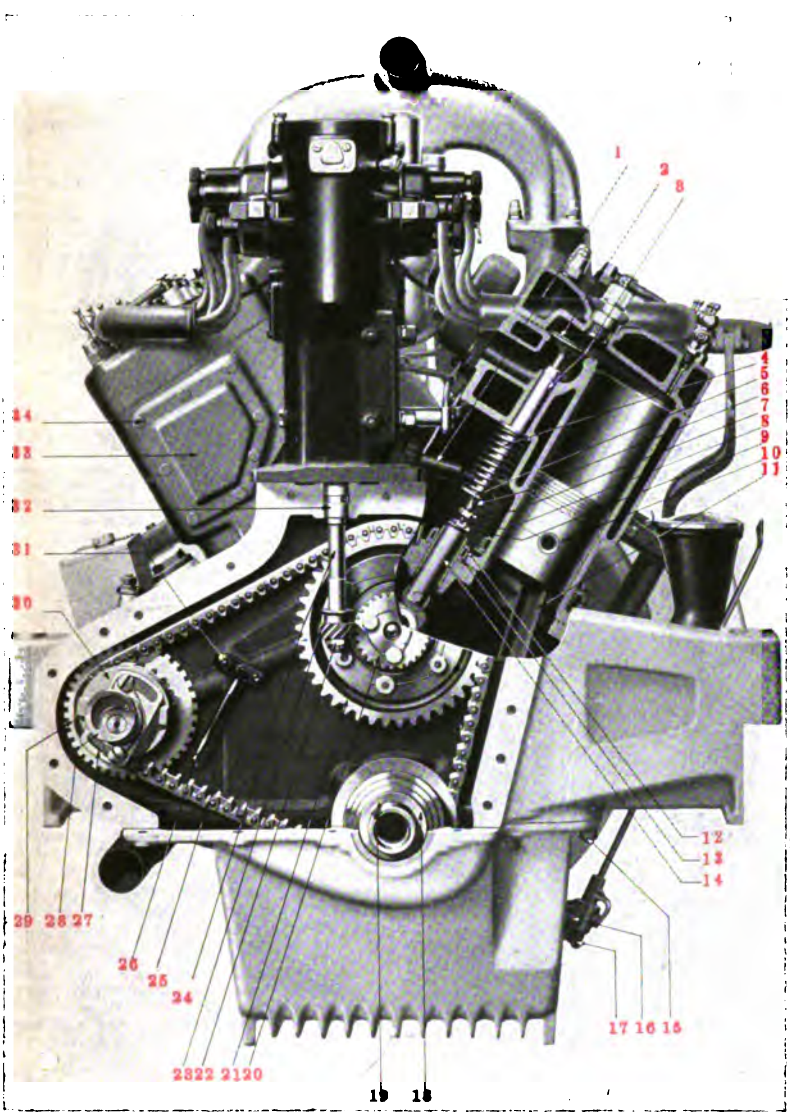
1 Fan.
2 Distributor bearing oiler.
3 Distributor.
4 Distributor spiral gear oiler.
5 Cylinder pet cock.
6 Ignition spark plug assembly.
7 Cylinder inlet manifold gasket.
8 Cylinder inlet manifold stud nut.
9 Cylinder inlet manifold.
10 Cylinder head stud nut.
11 Ignition high tension cable tube, left, assembly.
12 Cylinder water jacket plate.
13 Exhaust manifold, left.
14 Exhaust manifold, right.
15 Ignition high tension cable tube, right, assembly.
16 Clutch pedal pad.
17 Foot brake pedal pad.
18 Motor starter switch.
19 Clutch and brake pedal oiler.
20 Clutch cover.
21 Tire pump.
22 Transmission case oil filler plug.
23 Transmission gear shifter interlocking plunger retainer.
24 Transmission driving shaft rear bearing housing.
25 Speedometer driven gear shaft bearing.
26 Transmission driving shaft universal joint shaft flange.
27 Transmission reversing pinion pin.
28 Tire pump gear shifter lever retracting spring.
29 Tire pump case end cap.
30 Clutch shifter lever connecting yoke end adjusting wing nut.
31 Clutch shifter end bearing oiler.
32 Clutch shifter lever.
33 Clutch shifter lever connecting yoke end—adjusting spring.
34 Clutch shifter lever connecting yoke end—adjusting.
35 Foot brake pedal.
36 Clutch pedal.
37 Oil pump.
38 Exhaust manifold extension.
39 Crank case, lower half.
40 Cylinder water inlet manifold, left.
41 Crank case overflow valve assembly.
42 Crank case overflow valve handle.
43 Crank case oil filler assembly.
44 Fan belt.

CHART NO. 889—Left Side of Packard Engine.
Chart 888 omitted (error in numbering).



1 Transmission case cover oil filler plug.
2 Change speed lever ball.
3 Change speed lever.
4 Transmission case cover.
5 Motor starter switch.
6 Cylinder and core plugs assembly.
7 Cylinder head, core plugs and studs assembly.
8 Cylinder head gasket.
9 Valve, inlet.
10 Valve, exhaust.
11 Piston.
12 Distributor spiral gear oiler.
13 Distributor.
14 Fan.
15 Gasoline power pressure pump assembly.
16 Gasoline power pressure pump check valve inlet elbow.
17 Crank case cam shaft driving chain inspection hole plug.
18 Motor generator sprocket eccentric lock stud.
19 Motor generator sprocket eccentric clamp nut lock.
20 Vibration dampener flywheel.
21 Motor generator regulator.
22 Motor generator.
23 Motor generator oiler.
24 Water pump shaft grease cup.
25 Water pump inlet elbow assembly.
26 Water pump assembly.
27 Cylinder water inlet manifold, right.
28 Water pump inlet elbow drain cock.
29 Oil strainer cover.
30 Starter motor.
31 Crank case oil hole plug.
32 Motor starter oiler.
33 Clutch shifter end bearing, right.
34 Clutch shifter end bearing, oil cup.
35 Transmission case oil drain plug.
36 Transmission counter shaft rear bearing housing cover.

CHART NO. 390—Right Side of Packard Engine.



1 Valve cover stud nut assembly.
2 Valve—exhaust.
3 Valve stem guide.
4 Valve spring.
5 Valve spring collar.
6 Valve spring collar key.
7 Valve roller holder screw.
8 Valve roller holder screw check nut.
9 Valve roller holder screw plate.
10 Piston pin.
11 Connecting rod.
12 Valve roller holder guide yoke.
13 Valve roller holder guide.
14 Valve roller holder and roller assembly.
15 Crank case upper to lower stud nut.
16 Crank case overflow valve stud nut.
17 Crank case overflow valve spring.
18 Crank shaft oil thrower.
19 Fan driving pulley key.
20 Cam shaft spiral gear, front.
21 Cam shaft sprocket.
22 Distributor driving shaft nut.
23 Distributor driving shaft gear.
24 Distributor driving shaft.
25 Cam shaft driving chain.
26 Cam shaft driving chain oil tube assembly.
27 Gasoline power pressure pump eccentric lock.
28 Gasoline power pressure pump eccentric.
29 Motor generator sprocket eccentric.
30 Motor generator sprocket coupling, female.
31 Cam shaft driving chain oil tube flange nut.
32 Distributor driving shaft bushing, upper.
33 Cylinder water jacket plate.
34 Cylinder water jacket plate screw.

Engine Features.

The twin-six engine is of the four-cycle type with two blocks of L head cylinders bolted to the crank case at an inclined angle of sixty degrees. The cylinder bore is 3 inches and the stroke 5 inches. The left block is set 1¼-inch ahead of the right block to permit the lower end connecting rod bearings from opposite cylinders being placed side by side on the same crank pin. This arrangement also permits the use of a single cam shaft with a separate cam for each valve operating directly on the valve push rod roller.

Compression in all cylinders should be equal and up to the standard. Weakness or loss of compression is most probably due to imperfectly seated valves, which may be caused by insufficient clearance between the valve stems and lift rods, carbon deposits on the valve seats, or by sticky valve stems and guides. Compression should be tested for uniformity in all cylinders at regular intervals.

To test the compression in a cylinder, remove the spark plug and replace it with a standard compression gauge. Then with the ignition switch off and pet cocks in all cylinders closed, crank the motor, using the electric starter. At cranking speed with the engine cold, the gauge should register 75 pounds plus or minus 3 pounds with the throttle wide open.

A change in the setting of the cam shaft is possible only by removal or disarrangement of the front end chain. Adjustments to the chain do not affect the valve timing.

In resetting the cam shaft, the arrows on both the crank shaft and cam shaft gears should point directly upward and should be in line with the arrow on the front end cover face of the engine. In this position, the inscription on the fly-wheel, "Exhaust closes 1 and 6-R," will be on the top dead center line of the engine, which is the center between the two cylinder blocks, and No. 1 right piston will be in the firing position.

The main and connecting rod bearings are of the babbit-faced bronze type. The bearings are set with a .0015 to .002-inch clearance and are consequently flooded with a film of oil between the shaft and the bearing surface, making adjustment for wear necessary only at long intervals.

To grind the valves disconnect carburetor inlet manifold and spark plug connections and remove cylinder heads.

CHART NO. 391—Packard Engine, Front View.

Gasoline System.

General principle: The supply of gasoline is carried in the tank at the rear of the frame. The gasoline is supplied from the tank to the carburetor by air pressure provided by an air pump attached to the engine front end cover and driven by the forward extension of the generator shaft.

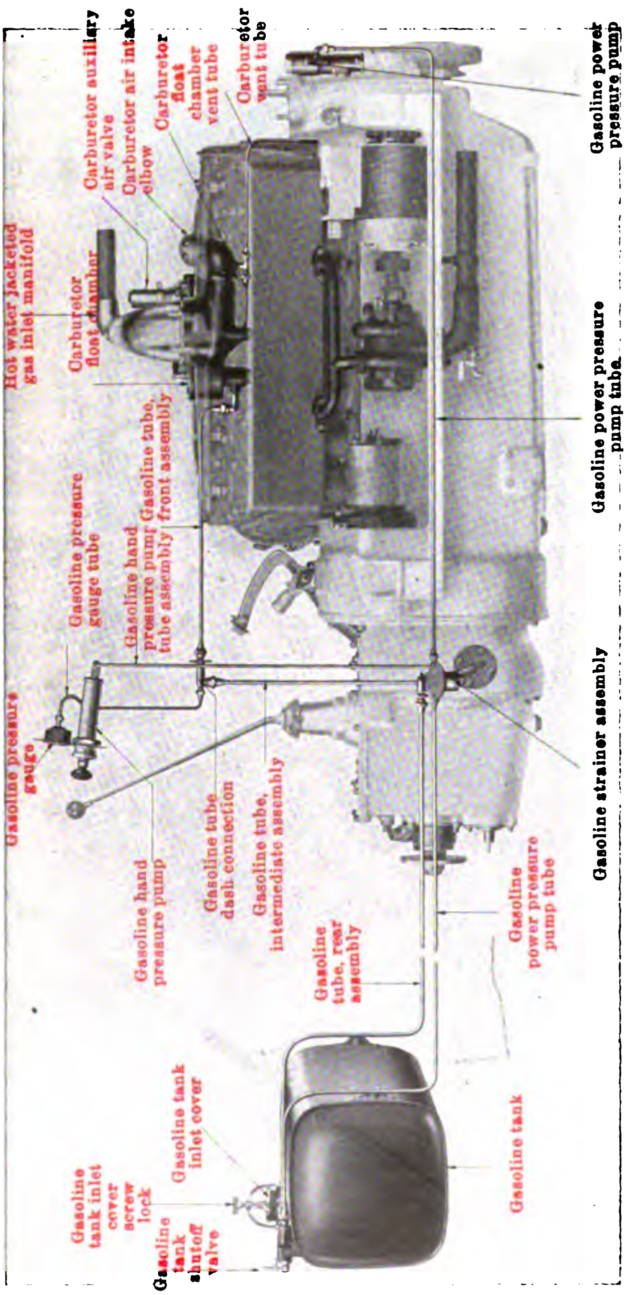
The carburetor is mounted above and between the cylinder blocks and receives the heat generated by the engine, which assists in the vaporization of the gasoline.

The gasoline tank is located on the rear of the frame. The capacity of the tank on all models is twenty gallons, including about a three-gallon reserve.

A three-way valve located on the top of the gasoline tank connects with outlet pipes leading to each side of the tank. Turning the valve handle to the right permits the gasoline to be completely drained from the right side of the tank and vice versa.

When gasoline has ceased to flow, turn valve handle to its opposite extreme regardless of the previous running position in order to obtain the reserve supply. Turning the handle straight up, shuts off the gasoline.

Caution: If gasoline tank has been completely drained and is replenished with less than five-gallon supply, turn the valve handle to the left, which is the side of the tank which receives the first three to five gallons. Otherwise, the gasoline will not flow.


Hot water jacketed gas inlet manifold
Carburetor float chamber
Carburetor auxiliary air valve
Carburetor air intake elbow
Carburetor float chamber vent tube
Carburetor vent tube
Gasoline power pressure pump
Gasoline tube, front assembly
Gasoline hand pressure pump tube assembly
Gasoline pressure gauge tube
Gasoline power pressure pump tube
Gasoline pressure gauge
Gasoline hand pressure pump
Gasoline tube dash connection
Gasoline tube, intermediate assembly
Gasoline strainer assembly
Gasoline tube, rear assembly
Gasoline power pressure pump tube
Gasoline tank inlet cover screw lock
Gasoline tank inlet cover
Gasoline tank shutoff valve
Gasoline tank

ART NO. 892—Diagram of Gasoline Pressure System.

Air pressure for supplying gasoline to the carburetor is furnished by an air pump attached to the crank case front end cover, and driven by an eccentric mounted on the generator shaft.

The air is drawn from outside the crank case and forced under pressure to the gasoline tank. To increase the pressure, remove the plug at the top of the pump cylinder and unscrew the smaller plug at its base. To decrease the pressure, the small plug should be screwed down.

The hand or auxiliary pump on the **instrument** board provides a means of obtaining initial air pressure before the engine is started, providing the gauge on the dash shows that there is no air pressure in the gasoline tank.

To obtain pressure by hand, unscrew the handle to the left. When plunger is free, operate pump until pressure shows on the gauge. Do not pump higher than 2½ pounds pressure.

If the gasoline gauge does not respond to the hand pressure pump, it is probably caused by the tank outlet valve being shut off.

Caution: When through operating pump, push plunger in and be sure to lock it in place by screwing plunger handle to the right.

The plunger leather of the pump should be oiled occasionally with neat's-foot oil. Mineral oils improve the operation of the pump only temporarily and tend to dry up the leather.

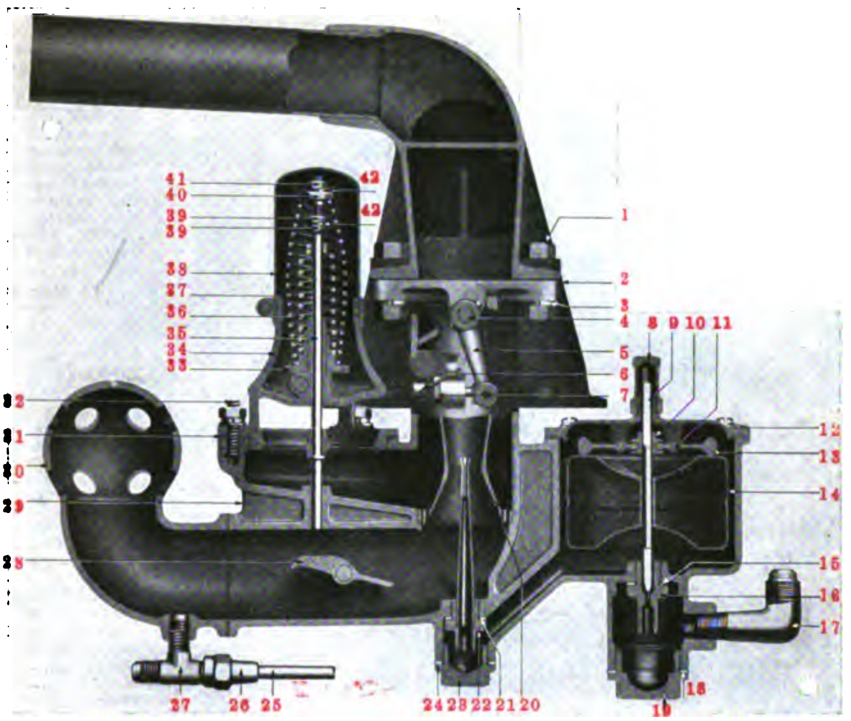
A gasoline pressure gauge on the instrument board is connected directly with the supply line at the **gasoline strainer housing. The gauge** indicator should show from 1½ to 2½ pounds pressure when the engine is running.

If the pressure gauge indicates that the pump is not maintaining the proper pressure in the tank, proceed as follows:

Inspect gasoline tank filler cap, seat and gasket to make sure that they are in good, clean condition and free from nicks.

Be sure that the filler cap is tightly seated. If the trouble is not found by the above method, examine all connections on the air pressure and gasoline supply lines to make sure that there are no leaks. A good method of locating leaks in the air line is to put pressure in the tank and go over the line carefully with soap suds.

If it is determined that all pipes and connections are absolutely air tight, raise the air pressure by adjusting the pump as described above.



1 Carburetor to inlet manifold screw.
2 Carburetor to inlet manifold gasket.
3 Carburetor to inlet manifold screw lock washer.
4 Carburetor throttle valve shaft assembly.
5 Carburetor throttle valve lever.
6 Carburetor throttle valve adjusting screw.
7 Carburetor throttle valve adjusting screw lock nut.
8 Carburetor float chamber needle valve cap.
9 Carburetor float chamber needle valve.
10 Carburetor float chamber needle valve collar.
11 Carburetor float balance weight pivot.
12 Carburetor cover screw.
13 Carburetor float balance weight.
14 Carburetor float assembly.
15 Carburetor float chamber needle valve seat gasket.
16 Carburetor float chamber needle valve seat.
17 Carburetor float chamber inlet tube elbow.
18 Carburetor float chamber filter well gasket.
19 Carburetor float chamber filter well.
20 Carburetor spray mixing tube.
21 Carburetor spray tube gasket.
22 Carburetor spray tube assembly.
23 Carburetor body plug.
24 Carburetor body plug gasket.
25 Carburetor float chamber vent tube assembly.
26 Carburetor float chamber vent tube union nut.
27 Carburetor vent tube union tee.
28 Carburetor air shutter.
29 Carburetor body.
30 Carburetor air intake elbow.
31 Carburetor air valve seat gasket.
32 Carburetor air valve seat stud, short.
33 Carburetor air valve cam collar.
34 Carburetor air valve seat.
35 Carburetor air valve assembly.
36 Carburetor air valve spring, small.
37 Carburetor air valve spring, large.
38 Carburetor air valve spring cap assembly.
39 Carburetor air valve adjusting nut lock nut.
40 Carburetor air valve adjusting nut.
41 Carburetor air valve spring (small) adjusting nut.
42 Carburetor air valve spring (small) adjusting nut lock washer.

Explanation of Carburetor Air Valves.

The primary air intake elbow (30) is at the front end of the carburetor.

The elbow contains a shutter (28) which is normally open and not in use when running.

This shutter is operated by the carburetor control on the instrument board, which also operates the auxiliary air valve.

By pulling the control all the way out, the primary air intake is completely closed, allowing a very rich mixture to be drawn into the cylinders. The control should be pushed in, at least part way as soon as the engine has started firing.

The auxiliary air valve (34 to 42) is in a housing forward of the mixing chamber and is controlled by the tension of two springs, one of which is within the other.

At low engine speed most of the air is admitted through the primary air intake around the spray nozzle.

To prevent too rich a mixture at a greater throttle opening, the auxiliary air valve is opened by the increase in vacuum, admitting the right proportion of air to meet all conditions.

Changing the tension of the springs will affect the amount of air passing through the auxiliary air valve.

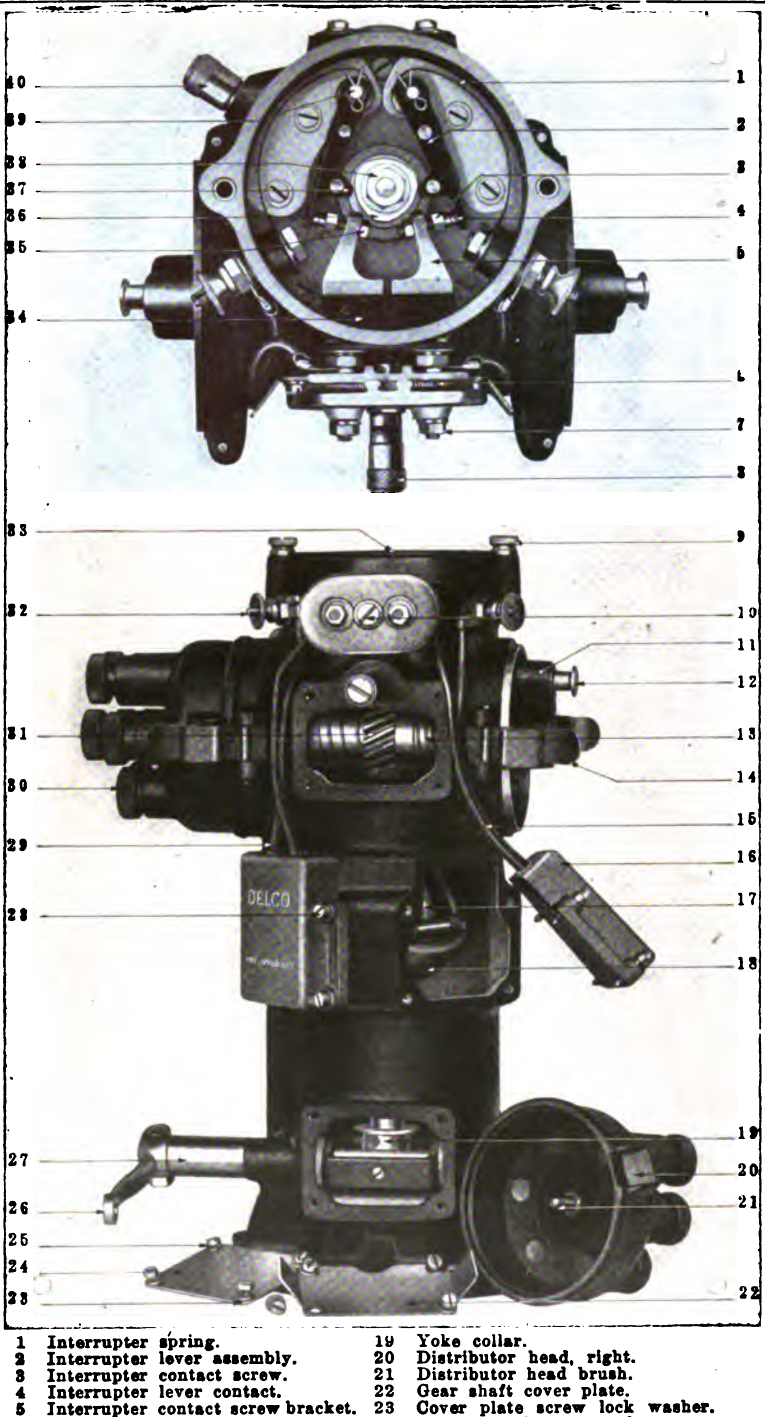
Adjustments of the auxiliary air valve are made by changing the tension of the air valve springs (36 and 37). These springs which control the action of the valve are adjusted by means of cams placed beneath them and operated by the air valve control on the instrument board.

The proper adjustment for normal running conditions is obtained when the control on the instrument board is in No. 4 notch. Adjustments for atmospheric conditions and starting the engine may be made by pulling out or pushing in the control the required number of notches. To enrich the mixture, pull the control out, pushing it in provides more air.

Caution: In warm weather or if the engine is warm, the mixture may be so rich if the knob is pulled out that the charge will not ignite and the surplus of unburned gasoline may interfere with the proper lubrication of the cylinder walls.

CHART NO. 898—Packard Carburetor.

*See also page 850 "Auxiliary Air Valve."



Ignition Interrupters.

The twin interrupter or breaker, at the top of the distributor unit, completes the low tension circuit when the breaker points are in contact. When the points separate, the instantaneous clearing of the low tension current from the primary winding of the coil, induces a high tension current in the secondary winding, which surrounds the primary winding.

This high tension current is then conducted to the cylinder spark plugs through the distributor leads.

The breaker or interrupter mechanism consists of a separate set of breaker points for each low tension circuit. These are operated by a single three-lobed cam (36) mounted on the top of a vertical shaft which is driven at crank shaft speed. This causes each low tension circuit to be broken three times to each revolution of the crank shaft.

Arcing across the contact points when they are separating is minimised by the use of separate condensers (16 and 28) for each set of breaker points, located in the rear side of the ignition timer and distributor housing. Indirectly these condensers also serve to intensify the high tension current wave. Resistance units (6) in both low tension circuits, and located on either side of the common ground return terminal on the timer housing serves to keep the low tension current down to the proper rate of flow.

High Tension Distributors.

Separate high tension distributor heads are provided for each cylinder block. These are mounted on either side of the ignition apparatus housing and are operated by rotors on a cross shaft driven from the vertical timer shaft (see page 853).

Firing Order.

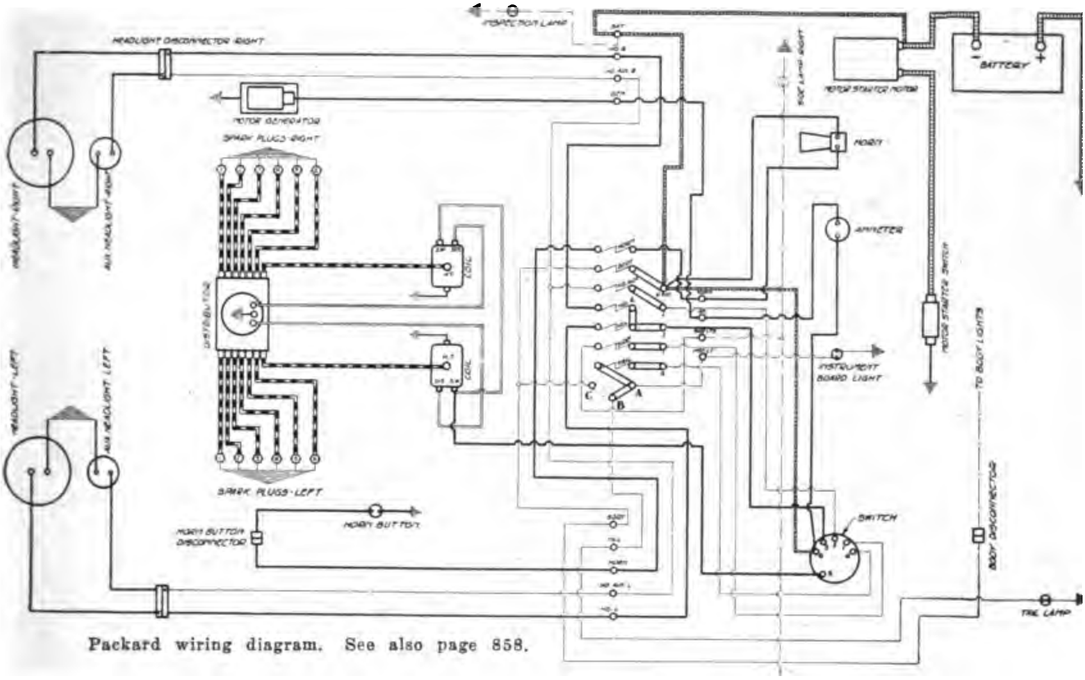
The firing order in each block is 1; 4; 2; 6; 3; 5; the impulses alternating between the two blocks. Numbering the cylinders in succession, beginning with number one at the front of the right block, the firing order would be 1R; 6L; 4R; 3L; 2R; 5L; 6R; 1L; 3R; 4L; 5R; 2L; the R and L designating the right and left cylinder blocks. (see page 135 for 1917 Packard firing order.)

1 Interrupter spring.
2 Interrupter lever assembly.
3 Interrupter contact screw.
4 Interrupter lever contact.
5 Interrupter contact screw bracket.
6 Resistance wire.
7 Interrupter screw bracket stud nut.
8 Spiral gear oiler.
9 Top cover screw.
10 Grounding screw.
11 Distributor brush holder assembly.
12 Distributor brush.
13 Distributor brush shaft spring, right.
14 Distributor head spring clip.
15 Condenser cable, short, assembly.
16 Condenser, right, assembly.
17 Governor link.
18 Governor weight assembly.
19 Yoke collar.
20 Distributor head, right.
21 Distributor head brush.
22 Gear shaft cover plate.
23 Cover plate screw lock washer.
24 Advance yoke cover plate.
25 Advance yoke cover plate screw.
26 Advance lever.
27 Advance lever spacer.
28 Condenser stud.
29 Condenser cable, long assembly.
30 Distributor high tension terminal nut.
31 Distributor brush shaft gear.
32 Low tension terminal stud nut.
33 Top cover plate assembly.
34 Interrupter bracket insulator.
35 Interrupter contact screw lock nut.
36 Interrupter cam.
37 Interrupter lever block.
38 Interrupter cam nut.
39 Interrupter lever stud.
40 Bearing oiler.

NO. 394—Packard Ignition Unit. Interrupter and Distributor. Packard-Delco System.

377 and 378 for general principle of the Delco single timer. See also page 135 for 1917 Packard ming—see pages 850 and 135.

*Packard Electric System.



Packard wiring diagram. See also page 858.

Battery and Generator.

A 6 volt storage battery of 120 ampere hour capacity supplies current for lights and ignition when car is running at low speeds. The positive pole is grounded. Negative terminal connects with starter motor.

The generator charges the storage battery and supplies current for lights at higher speeds.

Generator regulator is located on top of generator. It is provided with three split pins which fit into the three terminal tubes on top of the generator body. This regulator box contains an automatic "cut-out" which opens the circuit between generator and battery at low speeds.

The generator regulator keeps a constant electrical pressure or voltage, slightly higher than the voltage maintained by a fully charged battery, this pressure being maintained regardless of speed.

The voltage being constant, the current generated naturally varies, being small when the battery is fully charged and increasing as the lights are turned on or the battery is partially discharged. The disconnect switch should be reversed every 1,000 miles in order to keep the points clean on the automatic switch.

The Bijur system is an electrical system with a polarity reversing switch. In this system, if we assume the generator to be at rest, then the reversal of the polarity reversing switch actually reverses the battery connections at the point where the generator charging lines leave the voltage regulator. When the generator starts to revolve it builds up a potential in the same direction that it had before reversal. At the instant the automatic switch closes, the battery voltage predominates and the momentary discharge reverses the shunt field and at the same time the battery current through the armature reverses it so that the polarity of the generator is reversed. As the connections between the battery and generator have been reversed through the polarity reversing switch, the generator charges the battery in the proper direction.

Electric Starter.

Starting motor is the Bijur automatic gear shift principle explained on page 328, and illustrated on page 858. Note fly wheel drive for starting. **Starter switch** is attached to top of crank case. Button protrudes through the board. It is operated by foot. One terminal is grounded. Other connects with battery, but by a terminal on starting motor.

Fuse Board.

All lamp circuits and horn circuit pass through the fuse board on the front side of dash. When lamps or horn fails, examine fuses. If fuse is o. k., then look for loose wires. **Fuses** are glass tube type. If fuses continually blow look for a short circuit causing it.

Ammeter.

The ammeter is located on the instrument board. It is connected between the generator and battery through the switch; thus, with the engine idle, the ammeter does not indicate whether the lights are on or off. Should it register to the left of zero with the engine idle, remove the disconnect plug from the regulator, to prevent discharging the battery. When the engine is running the ammeter registers the amount of charging current passing from the generator to the storage battery and lights. If ammeter fails to register when engine is running about 750 revolutions or over 20 miles per hour, look for loose connections or broken wires between generator and battery, also see that generator commutator is clean and that brushes are making good contact. If ammeter shows a high current continuously of 25 or 30 amperes it indicates a heavy ground or short circuit in wiring or battery.

Disconnect the battery to prevent discharging and examine wiring for short circuits.

Electric Lighting.

All electric light appliances derive current through large cable leading from battery to starting motor, the other end of both lighting system and battery wires being grounded to complete the circuit.

Lamps—see page 434 for voltage and candle power of bulbs. The Ediswan base with single contact, page 433.

The tail and license lamp is so wired that it can either be turned on by a switch on the control board or by a revolving switch at the back of lamp.

In states (as Illinois) requiring the tail lamp to be turned on and off at the lamp, the connecting strap (A) on the fuse board should be connected to the terminal (C). In this case the circuit is controlled by the body light fuse, and the instrument board light by the tail lamp fuse.

Auxiliary headlights are smaller than the headlights. They are placed in front, to be used in place of headlights. The headlights are 24 c. p., 7 7 volt and the auxiliary headlights are 6 c. p., 7 volt. See diagram of wiring. They are sometimes called **dimmer** lights.

---

*For location of parts see illustrations on the different pages of Packard Supplement

Ignition System.

Is the single wire or grounded return. The source of current is the generator with a storage battery in the same circuit. The battery circuit is completed through the metallic parts of the chassis. **Ignition wires** are shown in red. Light red lines are low tension and heavy red lines, high tension.

High and low tension wires are distinguishable by difference in size, the low tension wires have thinner insulation and low tension current is carried in a complete one-wire circuit grounded at the contact screw brackets. The high tension current is grounded from the spark plug body through the engine, the coil bracket and through the end studs on the inboard **ends** of the coils on the dash.

High tension wires from distributors to spark plugs are carried in tubes supported on the cylinder blocks. The wires between the coils and distributors are carried in the same tube.

Low tension circuit: The negative battery terminal is connected to the upper post on the front of the starter motor. From this live terminal, the low tension current is carried to the terminal marked "BAT" on the front face of the small wiring board. On the rear side of the dash it passes from this terminal to the post marked "6-BAT" on the large wiring board. From this terminal it passes to No. 6 on the switch and leaves at No. 5, running to both coils which it enters at posts marked "SW" and leaves at posts marked "DIS." Independent circuits from these coils carry the current to the terminals on the interrupter housing and through the breaker levers to breaker contact points for each cylinder block.

The high tension current which originates in the secondary windings of the transformer coils passes from the terminal H. T. on the front of the coils to the center terminal of the distributor board, thence through the distributor to the appropriate spark plug. The high tension current after arcing the spark plug gap, completes the circuit through the spark plug body, cylinder castings and crank case to the grounded studs on inboard end of the coil.

The switch on the instrument board has two positions. A low tension circuit is completed through either one set of breaker points or the other, whenever the switch handle is turned to "Ignition," and the battery current flows continuously. The car should, therefore, never be left unattended with the switch in this position.

Spark advance is automatic similar to other Delco automatic systems.

For starting and ordinary running, the hand advance lever which shifts the entire range of action of the automatic spark advance, may be set and carried in the midway position. **For extremely low speed** it is advisable to carry this lever in the fully retarded position and for extremely high speed in the fully advanced position. For **maximum economy** above fifteen miles per hour the lever may be fully advanced.

Replacing ignition apparatus if removed: It is assumed that the spiral gear (23, page 853) has not been moved.

Place the fly-wheel in the position explained on page 850. Remove the right distributor head from the ignition apparatus and rotate the distributor arm until its position corresponds with the position of No. 1 terminal on the distributor head. The ignition timer may now be set in place.

Keep the lever, which is near the bottom left of the ignition apparatus, in its downward position. The ignition unit may now be set in place and all connections made.

Any necessary adjustments for connections can be made on the adjustable clevis at one end of both the horizontal and vertical spark control rods.

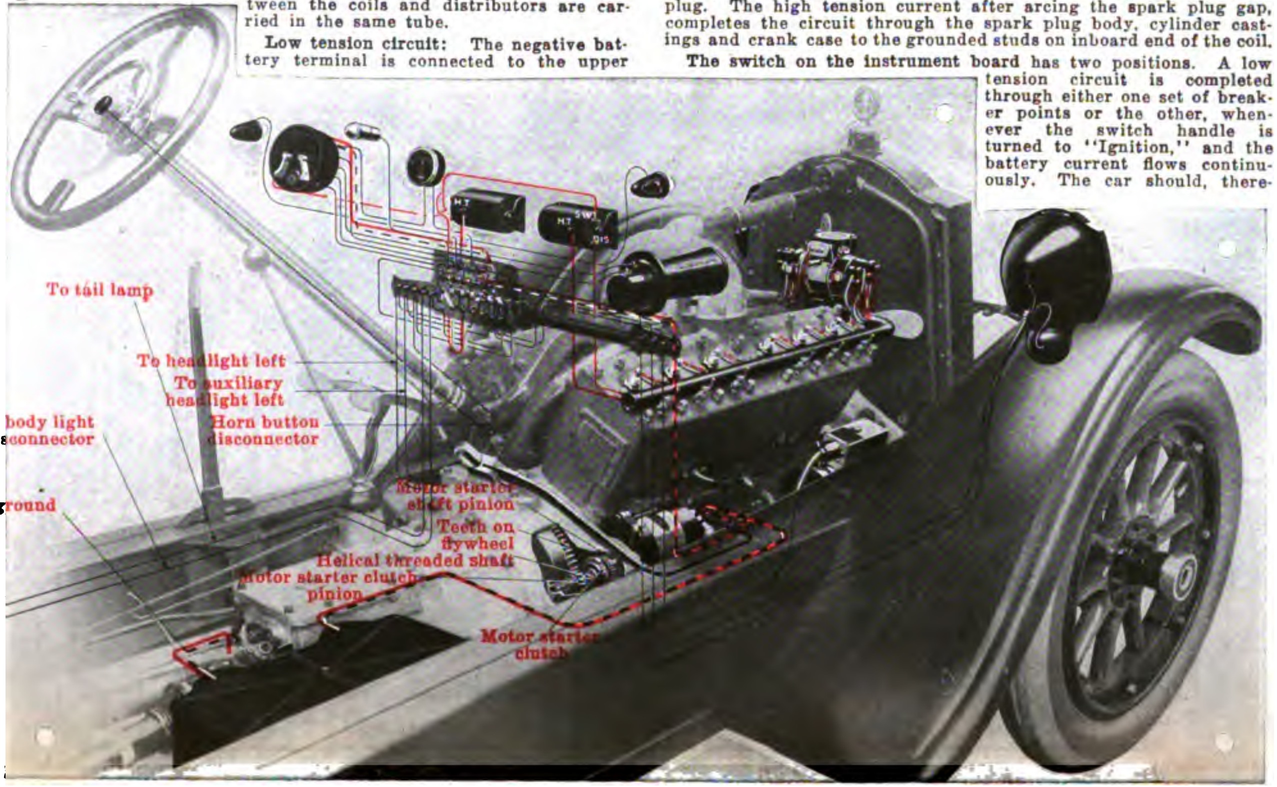
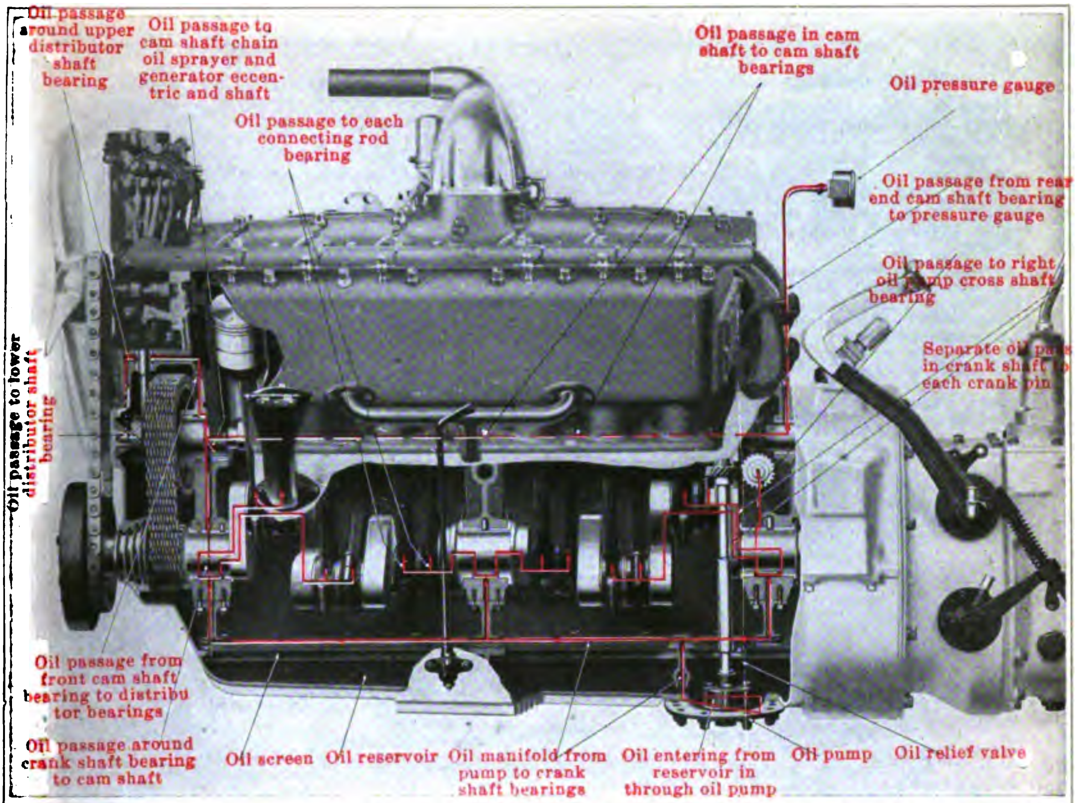


CHART NO. 395—Wiring View of Packard Electric System. Delco Ignition. Bijur Electric system otherwise. **Black wires above are starting and lighting wires. Light red, low tension ignition and heavy red, high tension ignition.**


Oil passage around upper distributor shaft bearing
Oil passage to cam shaft chain oil sprayer and generator eccentric and shaft
Oil passage to each connecting rod bearing
Oil passage in cam shaft to cam shaft bearings
Oil pressure gauge
Oil passage from rear end cam shaft bearing to pressure gauge
Oil passage to right oil pump cross shaft bearing
Separate oil pass in crank shaft to each crank pin
Oil passage to lower distributor shaft bearing
Oil passage from front cam shaft bearing to distributor bearings
Oil passage around crank shaft bearing to cam shaft
Oil screen
Oil reservoir
Oil manifold from pump to crank shaft bearings
Oil entering from reservoir in through oil pump
Oil pump
Oil relief valve

Principle of lubrication is force feed and is similar to the system described on page 198 (King).

Oil pump (see illustration below) is of the gear type. It is located at the lowest point of the oil pan and forces oil through a feed pipe to main oil distributor manifold, which is attached to the crank shaft bearing caps. See illustration above.

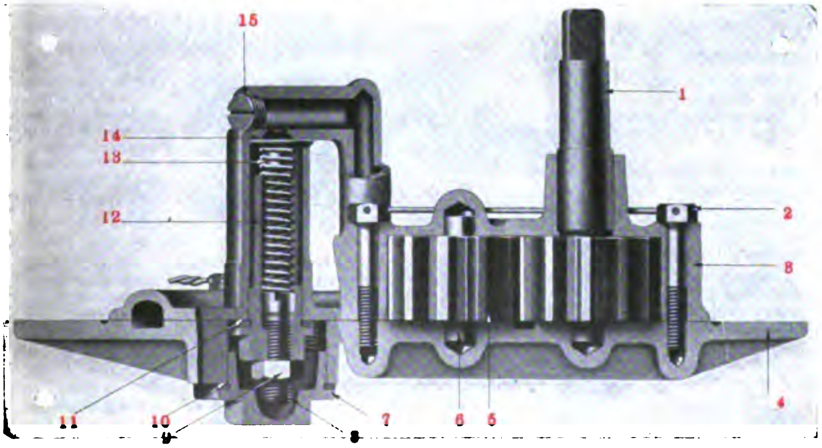
The pump is driven by a spiral gear on the cam **shaft.** It can be removed for inspection by removing nuts holding it.

The oil relief valve is contained in the pump body. It is controlled by the tension of a coiled spring which should be set to maintain a pressure of from 20 to 25 pounds with the engine warm and running at a speed of about 1,000 r. p. m., which is equivalent to a car speed of approximately twenty-five miles per hour, and with a minimum pressure of 5 pounds at 300 r. p. m. The inlet to the relief valve is connected with the pump discharge passage, and any excess pressure causes the valve to open and allows the oil to return to the inlet side of the pump.

To raise the oil pressure, remove the plug from the bottom of the pump housing; loosen the jamb nut on the adjusting stud and increase the spring tension, by turning the adjusting screw clockwise with a screw driver, until the proper pressure is obtained.

To lower the pressure, the spring tension should be decreased. Be sure jamb nut is screwed up tight before plug is replaced.

If the oil pressure drops below normal when the crank case oil supply is up to the proper level, the cylindrical strainer should be removed from the crank case and cleaned. It should also be cleaned whenever the supply of oil in the crank case is changed. **This can be done by removing the small plate from the right hand side of the crank case lower half, bearing the inscription, ''remove and disconnect oil manifold before taking off lower half of crank case.''**



1	Oil pump driving impeller assembly.
2	Oil pump body to base screw, long.
3	Oil pump body.
4	Oil pump base.
5	Oil pump driven impeller assembly.
6	Oil pump driven impeller shaft.
7	Oil pump base plug.
8	Relief valve spring adjusting screw.
9	Adjusting screw lock nut.
10	Base plug gasket.
11	Relief valve spring cap gasket.
12	Relief valve spring cap.
13	Relief valve spring.
14	Relief valve.
15	Body plug.

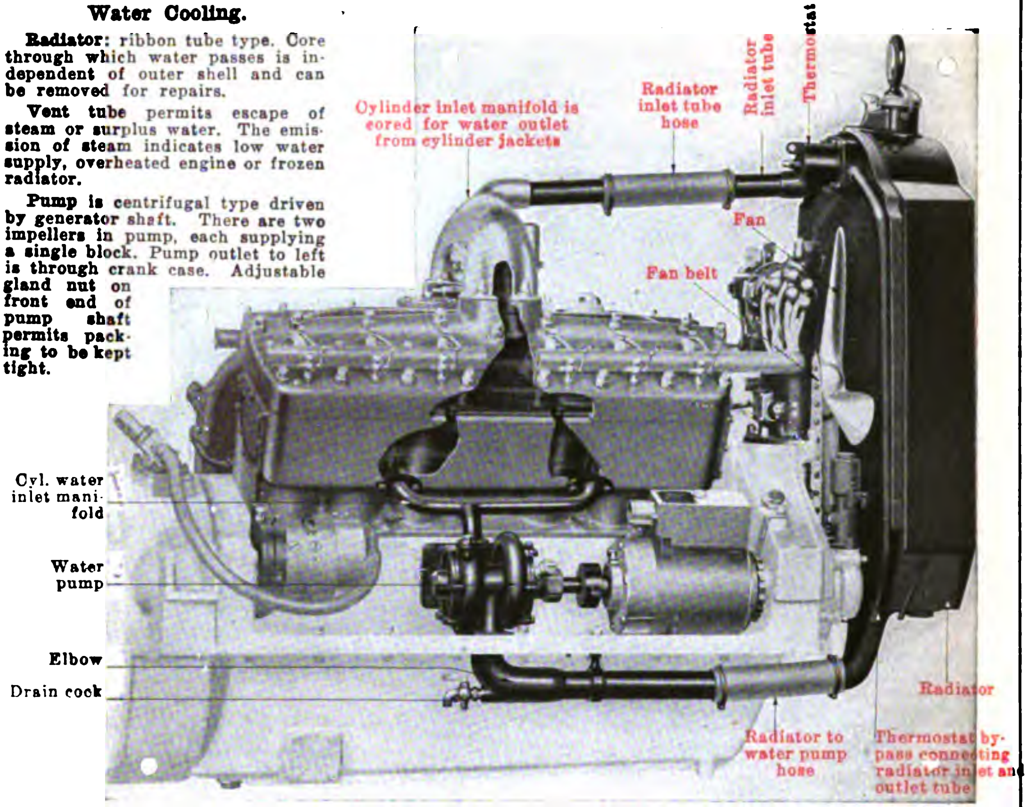
CHART NO. 396—Packard Engine Lubrication System. Oil Pump and Relief Valve.

Water Cooling.

Radiator: ribbon tube type. Core through which water passes is independent of outer shell and can be removed for repairs.

Vent tube permits escape of steam or surplus water. The emission of steam indicates low water supply, overheated engine or frozen radiator.

Pump is centrifugal type driven by generator shaft. There are two impellers in pump, each supplying a single block. Pump outlet to left is through crank case. Adjustable gland nut on front end of pump shaft permits packing to be kept tight.


Cylinder inlet manifold is cored for water outlet from cylinder jackets
Radiator inlet tube hose
Radiator inlet tube
Thermostat
Fan
Fan belt
Cyl. water inlet manifold
Water pump
Elbow
Drain cock
Radiator
Radiator to water pump hose
Thermostat by-pass connecting radiator inlet an outlet tube

How The Water Circulates.

The water is drawn from the bottom of the radiator by the double impeller pump and is distributed through the manifolds to each of the cylinder block water jackets. The outlet from the cylinder water jackets is through the cored water passage surrounding the gas intake header, which connects the cylinder blocks and thence through the tube leading to the top of the radiator.

The purpose of the water jacket surrounding the gas inlet manifold is to furnish heat to assist in vaporizing the gasoline.

*Packard Water Thermostat

Located in the upper tank of the radiator, by-passes the water to the inlet side of the pump until it has reached the proper temperature to permit efficient running of the engine.

A by-pass tube connects the thermostat housing with the inlet side of the water pump. Valves controlling the entrance to the radiator and the by-pass tube are carried on a shaft actuated by the action of the thermostat sylphon.

Normally when the water is cold, the radiator valve is closed and the by-pass inlet valve is open, allowing the water to circulate through the cylinder jackets and back to the pump without entering the radiator.

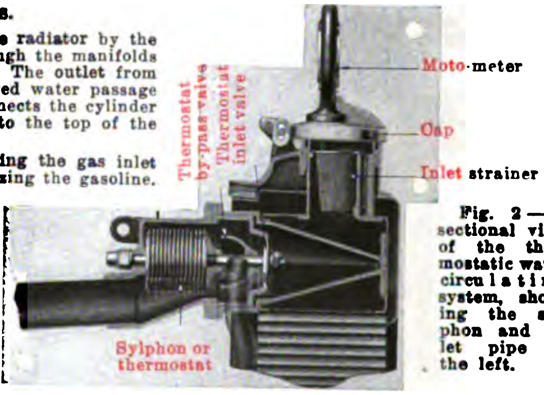


Fig. 2 — A sectional view of the thermostatic water circulating system, showing the sylphon and inlet pipe to the left.

As the water becomes heated, the expansion of the sylphon causes the radiator inlet valve to open, and at the same time closes the by-pass valve, making it necessary for all water to circulate through the radiator. No adjustment to the thermostat is necessary.

Clutch and Transmission.

Clutch: attached to the fly-wheel and enclosed in a housing bolted to the crank case casting is a multiple disc clutch. It consists of two series of dry plates which are alternately connected with a casing attached to the fly-wheel and with a spider on the clutch shaft. The casing or driving plates are faced with special friction material which contacts with the hardened and ground steel spider or driven plates.

The clutch plates are held in contact by the tension of a strong coil spring. Pressure upon the left pedal compresses the spring and allows the plates to separate slightly by sliding endwise on their respective keys, which connect the driving plates to the drum and the driven plates to the spider.

Transmission is the usual sliding gear type, giving three forward and one reverse speed. See page 498 for gear shift movements.

CHART NO. 397—Packard Water Circulating System.

*See page 130 for Cadillac water thermostat and pages 187 and 191. See page 730 for Cadillac condensing system.

INSTRUCTION No. 50.

DICTIONARY—Meaning of Motoring Terms.

Note:—If the Dictionary does not give the meaning, or if a description is desired,—see index for the subject.

A

Accumulators—A set of secondary cells—also called storage batteries,—containing positive and negative plates, and filled with electrolyte.

"Actual" horsepower is the amount of power that would be available if there was none absorbed by friction within the engine itself, and the total energy of the explosion was transmitted without friction or other losses to the engine shaft.

"Advanced" spark lever—see page 61.

A. L. A. M.—Means Associated Licensed Automobile Manufacturers. Now known as S. A. E. (Society of Automotive Engineers).

Alternating current—A current changing its direction of flow, or "alternating" backwards and forwards. The number of complete alternations are known as the cycles. Cut on page 266 shows just one cycle.

Aluminum—This metal, the chief characteristic of which is its lightness, is not generally used in its pure state, but is alloyed with a small proportion of zinc; sometimes, for special requirements, a small quantity of copper and manganese are added.

Ampere—The practical unit denoting the quantity of electricity. See page 207.

Ammeter—An instrument that indicates amperes or rate of current flow.

Ampere-hour capacity of a battery—is a term used to express the amount of current that can be gotten out of a battery of a given size. An actual 50 ampere-hour accumulator should be capable of giving 1 ampere for 50 hours, 2 amperes for 25 hours; but the ratio becomes disproportionate as a higher rate of current is taken from the cell.

Annealing—Softening of iron. By placing it in a fire and getting it red hot and then permitting it to cool without water it softens.

Annular ball bearing—see page 588.

Asbestos—This material is of mineral origin (large quantities come from Canada). In its natural state it is fibrous and somewhat brittle. As it resists great heat, it finds considerable application in motor work for engine jointing in the form of packing washers (of copper sheet and asbestos). Asbestos cord is used for covering exhaust pipes where these pass through woodwork, etc. Worked up into a fabric with brass wire, it is largely used for brake-band linings and clutch covering, as it cannot be burnt out by excessive friction.

Aviatrix—Feminine for Aviator. A woman who operates a flying machine.

B

Ballast resistor—see page 347.

Back-pressure—Term applied to restricted exhaust discharge. Unless muffler is of sufficient size there will be back pressure, and the exhaust will not be discharged as rapidly as it should.

Bezel—The groove in which the glass cover of speedometer or clock is fitted. (see page 512, upper right hand illustration.)

Bore and stroke—see page 81.

B. H. P.—Brake horsepower—Measurement of horsepower of an engine of actual net work of the engine or horsepower delivered at the shaft. (see page 536.)

British Thermal Unit, or B. T. U.—The amount of heat required to raise the temperature of 1 lb. of water 1 degree Fahr. (at its maximum density, which is at 39.1 degrees Fahr.) This expression is much referred to in the study of the value of various fuels for engines: thus petrol ranges about 20,000 B. T. U. per lb.

C

Calorific value—This term is used with reference to various fuels, such as gasoline, benzol, paraffin, etc., and represents the effective heating power per lb. in terms of British Thermal Units. One lb. of gasoline contains about 19,000 b. t. u's.

Cam shaft—The shaft running through the engine which has the cams placed upon it at certain fixed positions.

Carbon—One of the well-known non-metallic elements. It is an excellent conductor of electricity. As applied to the automobile refers to the carbon deposit which accumulates in the combustion chamber of an engine (see page 623). In a hard state it works well as a contact medium in conjunction with copper or brass, it is, therefore, largely used for the brushes of the magneto, and also for the brushes of car-lighting dynamos. Carbon in its natural form of graphite is used as a lubricant for gearing. It is generally mixed with grease, and is supplied ready prepared by lubricant manufacturers.

Carbonize—The deposit of carbon upon the points of the spark plugs and the various internal portions of engine cylinder and exhaust passages.

Cell—An electrical cell, is a vessel complete with its contents, and a number of these form a battery, or a set of storage batteries. Each cell must contain positive and negatve plates, and some form of electrolyte.

Celluloid—A compound of camphor and gun-cotton. Its transparency and flexibility are its chief characteristics. Non-inflammable celluloid is now made for windshields.

Chauffeur; pronounced "Sho-fur."—Derivation, French, chauffeur, to heat. A chauffeur is a man in charge of a furnace or. boiler fire The first use of the word chauffeur was during the revolution of 1789, when bands of brigands heated "chauffeur" the feet of their victims in order to make them reveal the place where their money was hidden. The "chauffeurs" were stamped out during the Consular period. The word chauffeur was first applied to motor car drivers under the popular supposition that they had to tend a fire. On the French railroads the chauffeur is the fireman; the engine driver is the mechanician.

Chauffeuse—A woman chauffeur.

Chassis; pronounced "chas-say."—Derivation, French; a frame in wood or metal; the frame work of a wagon; later the term was applied to the frame-work of a locomotive; then to the longitudinal and transverse frame members of a motor car. By extension it also designates the whole of the mechanical portion of a motor car. More correctly, however, the word chassis should only apply to the metal framework receiving the engine gearset and controlling mechanism.

Change gears—The transmission or system of changing the gears in gear box.

Chamfer—A small channel or groove cut in metal or wood; corner beveled off.

Check-valve—A stemless valve; one which permits the passage of a fluid or gas in one direction only.

Circuit—The path of the electrical current; the conducting material, or wires.

Circulating pump—Pump used to circulate the cooling water. Operated by the engine.

Clutch—A device for connecting and disconnecting the engine from the transmission—usually placed in or on the inner face of the fly wheel rim.

Clutch pedal—The foot pedal which connects and disconnects the clutch.

Coefficient—A known quantity. That which cooperates with another variable or unknown quantity.

Coil and battery system of ignition—In a battery the electricity is obtained by chemical means instead of mechanical means, as when a dynamo is used. The coil has nothing to do with the generation of the electric current, its function being to "gear up," intensify, or increase the pressure or transform the low-voltage primary current into a high voltage secondary current to enable a spark to be produced across the air gap of the plug points.

See page 439 for Storage Battery Words and Terms. See page 898 for **English-French Dictionary.**
By referring to index definition of many other words can be found. See page 907 for Airplane Glossary.

Combustion space—The space between the end of piston (when on upper dead center) and head of cylinder. That portion over the valve is also included. (see page 54.)

Compression—A term implying that the explosive charge of gas and air drawn into the cylinder on the suction stroke is subjected to a strong squeezing effect on the next stroke. The charge is pressed into a space about one-fifth the volume or space of that occupied by it on the suction stroke, equaling 80 lb. to 90 lb. pressure per square inch.

Compensating Air Valve—Also termed auxiliary air valve; a valve which counteracts the tendency of an over rich mixture as the speed increases.

Compensating Gear—see "Differential."

Compression tap or cock—A small tap placed at the upper end of the cylinder, which can be opened to relieve the compression, to make cranking easier.

Concentric—The opposite of eccentric.—(see foot note page 146.)

Condenser—An important part in a spark coil or high tension magneto. (see page 229.)

Conductor—A material along which electricity will readily flow, such as copper, platinum, steel, and, in fact, all metals. Silver is the best conductor, but copper is only very slightly inferior. Carbon is a non-metallic element, but an excellent conductor much used in magneto construction for the brushes. The wires or cables of the ignition circuit are sometimes referred to as conductors or "leads."

"**Contact breaker**"—The interrupter on a magneto. Also applied to the interrupter arrangement on the "make and break" igniter.

Contact-screw—The small screw, having a platinum point, against which the trembler vibrates.

Contact sector—One of the Sectors in a timer or distributor. (see (U) fig. 2, page 270.)

Continuous or direct current.—This implies that the current flows in one direction. The direct opposite of alternating current.

Current—The flow of electricity.

Cut-out, Muffler—A valve opening into the exhaust pipe at a point between it and the muffler when opened permits the exhaust gases to escape through it directly into the atmosphere instead of being forced through the muffler. (see page 84.)

Cylinder en bloc—The cylinders cast together in one piece.

Cylinder priming cock—Same as compression relief cock. Usually placed in the head of the cylinder for injecting gasoline.

D

Dead rear axle—A rear axle that does not turn. Type usually used on double chain driven cars.

Demountable rim—A form of rim that can be taken off the wheel without deflating the tire.

Differential gear. See page 85.

Direct current—Electric current where the current flows continuously in one direction. Unlike "alternating" current—the opposite.

Distributor or Distributer—A special form of rotary switch, which directs the high tension current to the various spark plugs.

Dry battery—Called dry cells or primary cells. A series of primary cells which do not contain liquid electrolyte.

Dynamo—A generator of electricity. The dynamo is usually used on a motor car to light the electric lights and to recharge storage batteries and in some instances furnishes current for the ignition.

E

Earth connection, or "ground"—An inaccurate term when applied to the electric circuits of a motorcar. The car is insulated from the road by the tires, hence the "earth" is not used at all. What is meant is that the framework of the car is used as a return conductor so as to dispense with some of the wires.

E. H. P.—Electric Horsepower. 746 Watts.

Electrode—The insulated part placed in the igniter of a low tension system of "make and break" ignition. The center rod of a spark plug. (see fig. 2, page 218 and fig. 1, page 216.)

Electric ignition—Any form of ignition by which the mixture in the combustion chamber is ignited by means of an electric spark.

Elements—See fig. 9, page 446.

Electro-magnet—Any piece of metal (usually iron or steel) that is magnetized electrically. The opposite of a permanent magnet.

E. M. F.—Electro Motive Force. The voltage. The pressure. Tension.

En-bloc—Cast in one piece.

E. P. M.—Explosions per minute of a gasoline engine.

Exhaust box—See muffler and silencer.

F

Field—The seat of magnetic flow, between the pole pieces of a generator or motor.

Pierce clutch—See page 661.

Flash point—See page 201.

Fly wheel—A heavy wheel rotating without contact with anything save its axle, by the momentum of the periphery of which, an even running of the engine is obtained.

Flux, magnetic—Lines of magnetic force, that pass or flow through a magnetic field. (see page 267. Also for welding, see page 719).

G

Galvanometer—An instrument for measuring the presence, extent, and direction of an electric current.

Garage; plural, garages—Derivation, French. The word has been taken bodily, pronunciation and spelling, from the French language, in which it is a variation of the word gare, a station or terminal for either railway trains or boats. Garage, as a noun, means, in both French and English, a place in which motor cars are kept and is sometimes applied to shops wherein motor cars are repaired. The verb, to garage, means the act of putting a car in the garage building. Pronounced with the final g soft, the final a open and the accent upon the last syllable.

Gasoline or gasolene—(English, gas; Lat. al (eum) (oil). A light grade of petroleum.

Gear box—See transmission.

Gear ratio—The number of revolutions of the engine made for one revolution of the road wheels—this depending on which "speed" or gear is in use. Thus the high speed gear ratio may be 4 to 1, i. e., four revolutions of the engine to one of the road wheels.

Gear set—The transmission.

Governor—A device to regulate the speed.

Ground—Connection of electric wiring to frame of car or metal part of engine. The term was originally derived from the fact that with telegraph and telephone systems one wire was used, which was insulated from the ground. The other, or return wire to complete the circuit, the ground was used. A piece of wire was attached to an iron pipe and driven deep into the ground at each end of the circuit. This same principle is used in automobiles. One wire is insulated from the frame or metal part of car The frame is used as the return wire.

Gudgeon pin—The wrist pin also referred to as the piston pin, the latter being correct term to use.

H

Half speed shaft—The small shaft, revolved at one-half the speed of the crank shaft by means of any suitable gearing—the cam shaft.

High gear—Combination of gears ordinarily used in running. The highest ratio of gearing—on some cars 2½ to 1. others 3 to 4½ to 1.

High tension and low tension—See page 213.

Hydro carbon engine—A gasoline engine.

I

Idling—Refers to engine when running slow, and car is standing still.

Ignition cam—The small cam on the half-speed shaft which either causes a make and break of the current, or is notched to receive the nose of the trembler in timers of the mechanical vibrator type. (see fig. 2, page 220.)

Igniter has various meanings. On "make and break" ignition the part that makes the spark. On high tension it sometimes means the spark plug and others call the "commutator" or "timer" the igniter. The correct meaning should be the part that ignites the gas.

Increments—Gradual increase or increasing a specified amount.

"Indicated" horsepower or I. H. P. is measured by taking an indicator diagram which shows the pressure of the explosion in pounds per square inch. From this the mean effective pressure during the stroke can be calculated.

Induced current—The momentary current set up in a circuit, by the the proximity of wires conveying the primary current, but not connected with those wires.

Induction—An influence exerted by an electrical charged body, or by a magnetic field or neighboring bodies without apparent communication or connection.

Induction coil—A step-up transformer. An apparatus through which the primary current is made to pass close to the secondary wires, thus setting up the induced, or high tension current. (see page 221.)

Inductor—See pages 256 and 265.

Intensify—To increase, to render more intense—to intensify the voltage (pressure) means to increase the voltage.

Inlet valve cage—A housing used over an inlet valve. (see figs. 2 and 3, page 90.)

Inspiration—Means the same as "suction" or "intake" as, suctión stroke, intake stroke, or inspiration stroke.

Insulation—The protection of wires, or leads, by some suitable material which is a non-conductor of electricity.

Insulator.—A material through which electricity cannot flow, for instance, porcelain, mica, india rubber, fibre, vulcanite, glass, celluloid, paraffin-wax, silk, shellac, steatite, slate, etc.

"Int."—When found stamped on a coil or terminal, means interrupter connection.

Integral—The whole made up of parts.

Intensity coil—See "Induction Coil."

Intermediate gear—Combination of gears intermediate in power and speed, between the low gear and the high gear.

Intermittent—Applied to a cam on the engine, meaning that the motion is not steady but at intervals.

Internal combustion engine—See page 53.

J-K.

Jump spark—A spark which jumps from one terminal of the secondary coil to the other. (see induction coil.)

Jump spark coil—Another name for induction coil, spark coil or high tension coil.

Jump spark plug—A plug used with the jump spark system.

Kilometer—1000 meters or ⅝ of a mile.

Kilo-watt—1000 watts or 1⅓ horsepower.

L

Laminate—Built up of thin plates of metal, as shims or a "laminated core in magneto armature." (see fig. 6, page 258.)

Lapping—A term applied to the operation of grinding in or fitting rings, pistons, etc.

Limousine; plural limousines—Derivation, French. A motor car body with a permanent top projecting over the driver and having a protecting front. The name was originally applied to a cloak worn by the inhabitants of Limousine, an old province of central France. It was later extended to the covering of a carriage, and then to one type of enclosed motor car body. At present, the term often is applied to a complete car having a limousine body. (see page 16.)

Lines of force—Imaginary lines, in the direction of which it is assumed that the lines of magnetic attraction and repulsion pass or act. (see page 267.)

Liners—Metal plates, usually very thin, placed betwen two halves of a bearing so that by taking out a liner the bearing can be tightened.

Live axle—Type generally used on shaft-driven cars. Axle turns.

Low speed—The ratio of gearing in a transmission for running rear axle at the lowest speed.

M

Magneto—A device operated mechanically and driven direct from the engine and which generates electric current but "alternating" instead of "direct." There are two forms; the low tension and the high tension.

"Make and break" ignition—Low tension system. No spark plugs used.

Manganese bronze.—Composed of copper, zinc and manganese. It makes very strong and tough castings. Forged front axles of this alloy are used on some American cars.

Mechanical efficiency is the ratio between the indicated h. p. and the h. p. available for useful work at the engine shaft.

Mechanician—A racing driver's helper. Also see page 594.

Mechanical equivalent of heat.—This is represented by the number 778, which is the number of foot pounds of work equivalent to one British thermal unit.

Mechanical valve—Applied to either the exhaust or inlet valves when operated by a cam or mechanical means. The exhaust valve is always mechanically operated, whereas the intake is sometimes opened automatically by the suction of the piston.

Mesh—Usually applied to the meshing of the teeth of two gears; for instance, the teeth of the large half time gear, in fig. 3, page 86, (G2), meshes with the drive gear (G1) on the crank shaft.

Misfiring—Term applied to missing of one of the spark plugs.

Mono-block cylinders—Another name for en-bloc or all in one casting.

Motor—The engine or motive power. Technically it refers to an electric motor and should never be used when referring to the engine.

N

Negative pole—Minus sign—The point to which the current returns after passing through the circuit. Designated thus: (—)

Nickel.—Used in the form of an alloy with steel, viz., nickel-steel. For exhaust valve a high perecentage (20 to 25%) nickel steel is the most suitable material, as it effectively resists the intense heat and oxidizing action of the exhaust gases. Nickel is now the standard material for sparking plug electrodes for the same reason.

O

O—A small (°) placed along side of a figure expresses degrees, see page 93 for meaning of degrees.

Ohm—A unit of electrical measurement of resistance. The resistance an electric current meets in flowing through a conductor, is measured in ohms. (see page 207.)

Oscillate—A pendulum like movement, see connecting rod, page 645.

Otto, or four stroke "cycle," is an expression often used in connection with gasoline engines. It means that the power is developed during a complete cycle or four strokes, the principle first adopted in the Otto gas engine. The complete cycle comprises four distinct operations, one occurring at each half revolution of every stroke of the piston: thus (1) suction stroke, (2) compression stroke, (3) impulse or firing stroke, and (4) exhausting stroke.

P

Parabolic—Pertaining to, or formed like a parabola. One of the conic sections.

Periphery—That part of a wheel or disk farthest from its center. The circumference.

Pet cock—(also called relief cock and compression cock)—A small valve usually placed in head of cylinder or on carburetor.

Petrol—Gasoline.

Phosphor-bronze—An alloy mainly consisting of copper and small proportions of tin, lead and phosphorus, the proportion of the latter being very small. It is a very tough, hard-wearing alloy. Largely used for engine bearings.

Pinions—Gears that have the teeth cut right in the hub.

Platinum.—This very expensive metal (price ranging from $30 to $40 per oz., according to the market) is used for the contacts of the magneto. It is practically infusible (it has a very high melting point) and non-corrodible, and thus effectively resists the burning and oxidizing action of the electric spark. It is also used for the "leading in" wires of the electric bulbs used for car lighting, as its ratio of expansion (due to heat) is the same as glass. Sparking plug electrodes are, in a few instances, also made of it. Tungsten now extensively used instead.

Porcelain—The insulating material of the spark plug.

Poppet valve—The word poppet probably is a corruption of the name puppet applied to this type in England, on account of its resemblance to the popping up and down of the puppets in the old time Punch and Judy shows. (see fig. 1, page 88.)

Positive pole.—Usually indicated with a plus sign (+) means the positive terminal, or wire from which the current starts in an accumulator or dynamo. The carbon terminal of a primary or dry battery is positive.

Port—Openings in the cylinder for exhaust, inlet, water, or valves.

Pre-Ignition—Ignition occurring earlier than intended.

Primary battery—A series of either wet or dry cells depending upon chemicals for the generation of electricity, without charging from a dynamo or other battery.

Primary wires—The wires, or leads, conducting the primary, or low tension, current to the place, or places, where it is required for use.

Propeller shaft—The drive shaft from transmission to rear axle. (see page 50.)

Q

Quadrant—Usually applied to the quarter circle on which the spark lever and throttle lever is attached on the steering wheel.

R

Reciprocating—A back and forth movement applied to the action of the pistons in the engine.

Rectifier—An electrical device for changing alternating, into direct current.

Resistor—(ballast)—(see fig. 3, page 348.)

Retard—A decrease in the speed of. Usually applied to "retarding the spark," meaning to set the timer back so that the ignition will be later or slower.

Rotary—Revolving motion; opposite of reciprocating motion.

Rotary valve—See page 138.

R. P. M.—Revolutions per minute.

Rubber.—For tire construction rubber supplies come from various parts of the world. Amongst the finest grades is the well-known "Para" or Brazil rubber. South America rubber, generally is considered very good, but excellent supplies now come from Borneo, India, Ceylon, Federated Malay States, and, in fact, many other tropical lands. Pure rubber lacks certain important physical characteristics indispensable for tires, such as stability under change of temperature. Pure rubber becomes soft under the influence of heat, and hard and brittle when subjected to cold. The process of vulcanization renders the rubber proof against heat and cold, and also renders it tough and resilient, so as to possess "life" and vibration absorbing properties.

S

Scored—Marred by ridges or grooves. Usually referred to in connection with cylinders, (see page 658.)

Seats—That part of chamber upon which the valve rests. Applied to the valve in engine.

Secondary battery—A storage battery.

Secondary coil—The winding in which the high tension current is generated, which is quite distinct from the primary current.

Short circuiting—Providing a shorter path; placing a wire or other conductor, from positive to negative side. (see page 412.)

Shunt—To turn aside or branch off. (see pages 332 and 414.)

Silencer—See Muffler.

Sleeve valve—See page 139.

Spark—The spark which passes between the points of the spark plug.

Spark coil—A coil through which electric current is passed and intensified. (see fig. 1, page 220.)

Spark control lever—The lever on the steering column (usually the short one) attached to the timer. (see page 152.)

Spark gap—A safety device on a magneto to prevent the armature windings being strained or short circuited owing to a faulty spark plug or wiring circuit, also applies to gap between points of spark plug.

Starting crank—A crank for starting the engine.

Starting plug—A small brass plug which fits into an opening on the dashboard and closes the circuit. When removed, the circuit is broken.

Streamline body—See page 760.

Stroke—Usually referred to as the stroke of an engine, meaning the length of the up and down motion of a piston.

Stroke of engine—See Bore (and pages 543 to 546.)

Studs—Bolts, with threads cut on both ends, screwed into engine cylinders to fasten them to base, also used to fasten down cylinder heads. (see fig. 1, page 701.)

Symbols—See pages 541, and 356.

Synchronization—To time two or more sparks to occur exactly at the same instant or at a similar period in a given cycle of operation. (see page 232).

T

Tappet—A push rod connected between the cam and valve. (see fig. 2, page 92.) Also termed a plunger.

Throw—Usually referred to as the crank, or the part where the big end of the connecting rod attaches to crank shaft.

Tonneau; plural, Tonneaux—Derivation, French word meaning a barrel; a wooden vessel formed of staves and hoops and made to contain a tonneau (1,000 kilogrammes) of oil. Later, a horsedrawn carriage, known in England as a governess car, having a rear entrance A similar type of body was first applied to a motor car by M. Huillier, of Paris, and by reason of its resemblance to a barrel and to the horsedrawn tonneau already existing, was known as a tonneau.

Torque—The word torque is a definite one and means the same whether referred to automobiles or any other piece of mechanism, and refers to the twisting or wrenching effect produced by the engine or motor.

Touche—The small plug used in the switch to complete the electrical circuit when required. (French.)

Transformer—Another name for a high tension coil. An electrical device for transforming the current from a low tension to a high tension. An induction or secondary or high tension, double wound, coil.

Trembler—The small vibrating spring used for making and breaking the primary circuit of a coil. (see page 220.)

Tube ignition—A small tube, usually of platinum —having its outer end closed—is screwed into the combustion chamber. This tube is so placed that the flame of a blow-lamp, generally supplied from a separate and small tank of gasoline, acts upon it and causes it to become incandescent. Old method of ignition now out of date.

Tuning an engine—Extreme care and special adjustment—as tuning up a car for a race, etc.

Two-to-one gear—The gearing—usually consisting of two-gear wheels, one having exactly double as many teeth as the other, also called "timing gears" and "halftime-gears."

V

Valve-lifter—An additional lever by means of which the exhaust valve may be raised and kept out of action, thereby reducing the compression and preventing the creation of a vacuum within the cylinder, so causing the inlet valve to remain closed. Used extensively on aero and stationary gasoline engines. This term also applies to a "valve spring lifter," (see page 633.)

Vaporizer—An early form of carburetor valve. See page 141, fig. 1. The vaporizer is also a means of heating the fuel.

Venturi—Applies to the mixing chamber of a carburetor; Venturi shaped—(see page 152, figs. 2 and 3.)

Viscosity—The adhesive or glutinous characteristic of oils used for lubrication.

W

Watt—The unit of electrical power obtained by multiplying volts by amperes. (see page 207.)

Wet-Cell—A battery using a liquid solution.

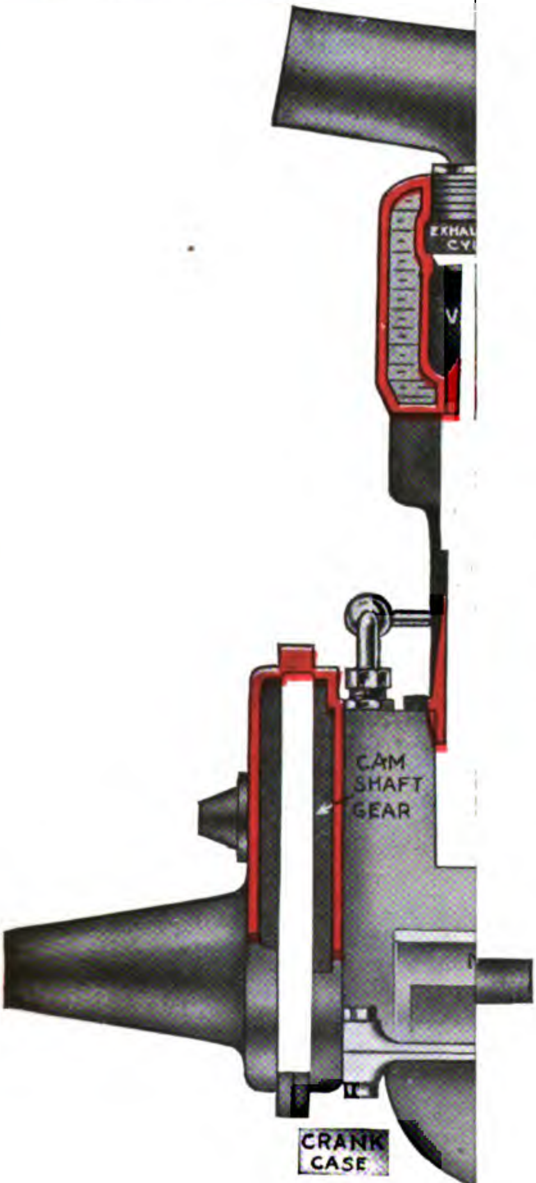
White metal or anti-friction metal—An easily fusible alloy of lead, antimony, and tin used for "lining" re-metalling bearings.

Draw in the other side first—then th

Valves—draw in the valve head in itarting down on power stroke (see page
116). Firing order we will say is 1, 2

Valve springs are next, then valve sp

Cam gears should now be drawn, thepiston was just starting down on power
stroke, No. 2 just starting up on coke.



Valve guides are drawn next, then **valve plungers**; on the upper part of valve **plungers** place adjustment nuts.

Lubrication system of the forced feed principle can now be outlined—the oil pump being operated from the cam shaft. Show arrows pointing in direction of flow of oil.

Ignition—a magneto of the high tension type* can be installed or a battery and coil system.

If battery and coil system, place the ignition unit (as per page 342) on the generator and place generator on the bracket (MG). Chains usually run the generator—but in this case we will use gears.

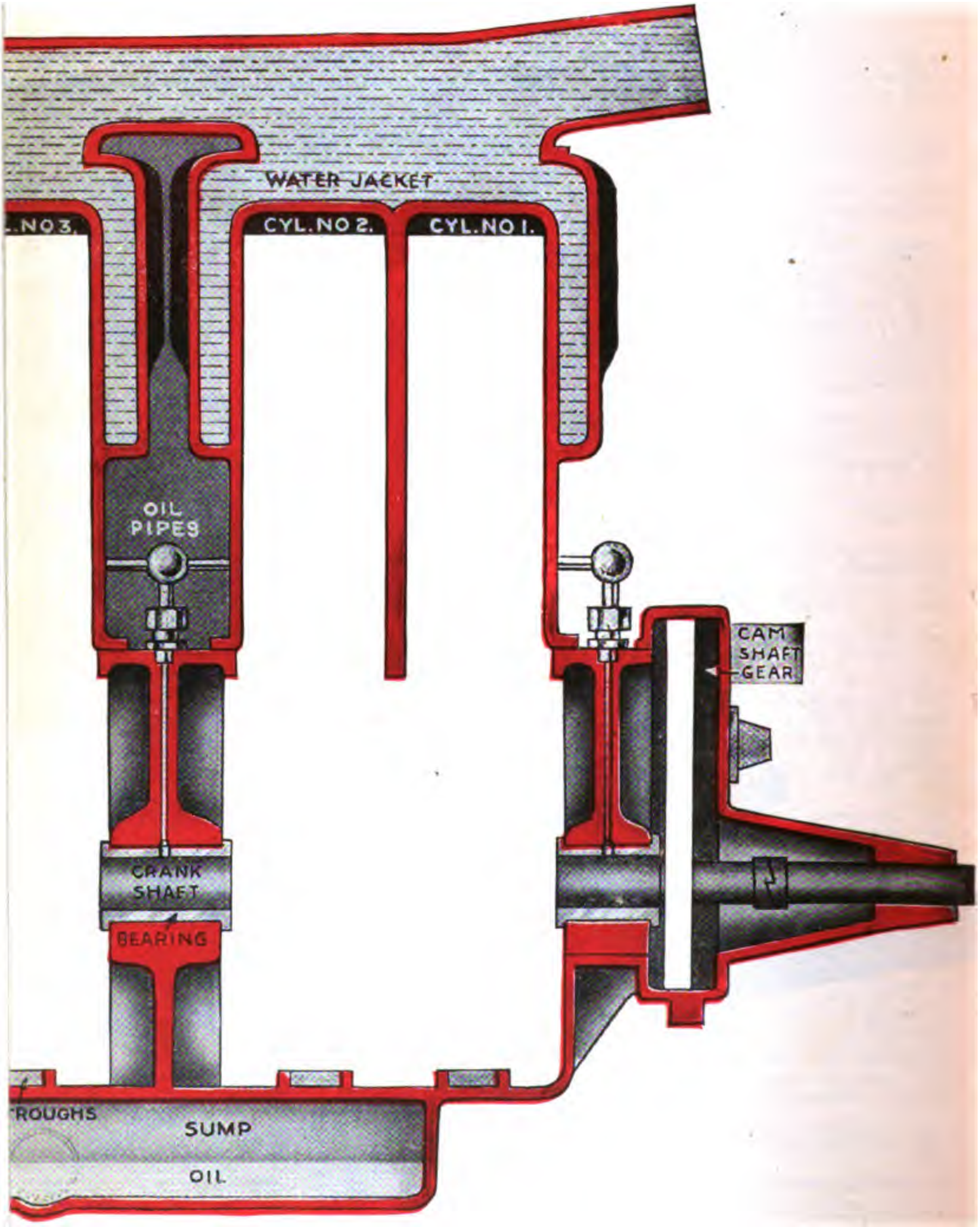
Connect up the wires from timer to battery (place a battery below some where), connect cables from distributor to spark plugs for a firing order of 1, 2, 4, 3.

Starting motor—place a starting motor using a Bendix drive (see page 342—and explanation pages 326-331) on the bracket (S)—connect this starter with battery and switch

*See illustrations, pages 310 and 266.

CYLINDER ENGINE—Draw in the Parts.

d their purpose, this illustration and the one on the back have been provided. If the d below.



The F. A. Starting and Lighting System as Installed on Ford Sedans and Coupes.

Parts and Location.

The starting and generator system is a two-unit type and consists of the following parts: Generator, cut-out, combination switch, fuse, terminal block, ammeter, starting motor, storage battery, wire, headlamps with headlight bulbs and dimmer bulbs. The combination switch, ammeter, and priming button are mounted on a cowl.

The Starting Motor.

The starting motor is mounted on the left-hand side of the engine and bolted to the transmission cover. When in operation the pinion on the *Bendix drive shaft engages with the teeth on the flywheel, which is a ring gear with teeth cut in it and bolted to flywheel and held in place by the brass screws which hold the magnets—see fig. 5, page 864B.

When Starting Engine.

The spark and throttle levers should be placed in the same position on the quadrant as when cranking by hand, and the ignition switch turned on. Current from either battery or magneto may be used for ignition. When starting, especially if the engine is cold, the ignition switch should be turned to "battery." As soon as the engine is warmed up, turn switch back to "magneto." The magneto was designed to furnish ignition for the Model T engine and better results will be obtained by operating in this way. Special attention must be paid to the position of the spark lever, as a too advanced spark will cause serious back firing which in turn will bend or break the shaft in the starter.

The starting motor is operated by a push button, conveniently located in the floor of the car at the driver's feet. With the spark and throttle levers in the proper position, and ignition switch turned on, press on the push button with the foot. This closes the circuit between the battery and starting motor, causing the pinion of the Bendix drive shaft to engage with the teeth on the flywheel, thus turning over the crank shaft.

When the engine is cold it may be necessary to prime it by pulling out the carburetor priming rod, which is located on the instrument board. In order to avoid flooding the engine with an over rich mixture of gas, the priming rod should only be held out for a few seconds at a time.

If Engine Fails To Start.

If the starting motor is turning the crank shaft over and the engine fails to start, the trouble is not in the starting system. In this
ent release the button at once so as not to
necessary discharge the battery, and in-
et the carburetor and ignition system to
rmine the trouble.

If Starting Motor Fails.

**the starting motor fails to act, after push-
the button,** first inspect the terminal on
starting motor, the two terminals on the
ttery and the two terminals on starting
itch, making sure all of the connections are
ht; then examine the wiring for a break in
insulation that would cause a short-cir-
t. If the wiring and connections are o. k. and the starting motor fails to act, test the battery with a hydrometer. If the hydrometer reading is less than 1.225 the trouble is no doubt due to a weak or discharged battery.

Operation of Generator.

The generator is mounted on the right-hand side of the engine and bolted to the cylinder front end cover. It is operated by the pinion on the armature shaft engaging with the large time gear (spiral gear).

The charging rate of generator is set so as to cut in at engine speeds corresponding to 10 miles per hour in high speed and reaches a maximum charging rate at 20 miles per hour. At higher speeds the charge will taper off, which is a settled characteristic of battery charging.

This operation of cutting in and cutting out at suitable speeds is accomplished by the cut-out. This cut-out is set properly at the factory and should not under any circumstances be tampered with.

Oiling.

The starting motor is lubricated by the Ford splash system, the same as the engine and transmission. The generator is lubricated by a splash of oil from the time gears. In addition an oil cup is located at the end of the generator housing and a few drops of oil should be applied occasionally.

When Tampering with the Ignition System.

The introduction of a battery current into the magneto will discharge the magnets and whenever repairing the ignition system or tampering with the wiring in any way, do not fail to disconnect the positive wire from the battery. The end of this wire should be wound with tape to prevent its coming in contact with the igniton system or metal parts of the car.

An Ampere Meter

is located on the instrument board or cowl and reading is 20-0-20 which means, 0 or zero is in the center and 20 to the left or "discharge" side and 20 to the right or "charge" side. (see page 410 for explanation.) The needle is on the "charge" side, when the generator is charging the battery and "discharge" side, when the lights are burning and the engine not running above 10 miles per hour.

At an engine speed of 15 miles per hour or more the meter should show a reading of from 10 to 12 amperes even with the lights burning.

If the engine is running above 15 miles per hour and the meter needle does not go to the "charge" side, first inspect the terminal posts on the meter, making sure that the connections are tight, then disconnect the wire from the terminal on generator, and with the engine running at a moderate speed, take a pair of pliers or a screw-driver and short-circuit the terminal stud on the generator to the generator housing. If the generator is o. k., a good live spark will be noted. (Do not run the engine any longer than is necessary with the terminal wire disconnected.)

---

he same principle as shown on pages 326, 331. See fig. 2, page 331, and note how spring is con-
cted with sleeve.

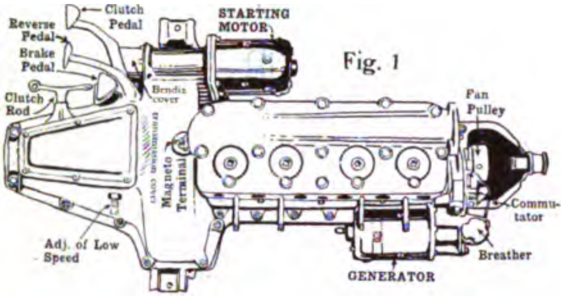


Fig. 1—Top view of Ford power plant.

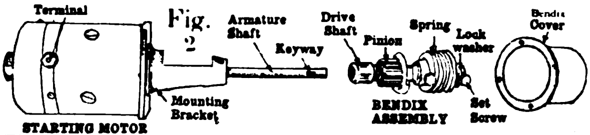


Fig. 2—Starting motor with Bendix drive parts removed from armature shaft.

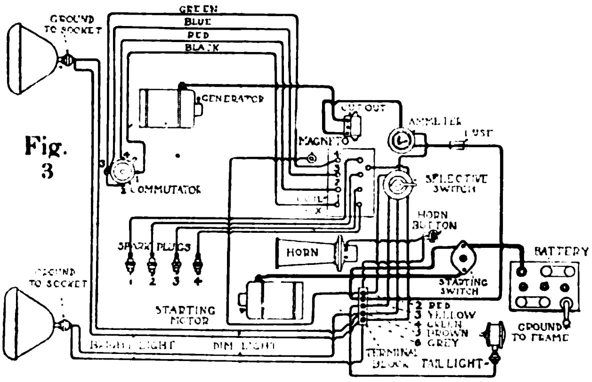
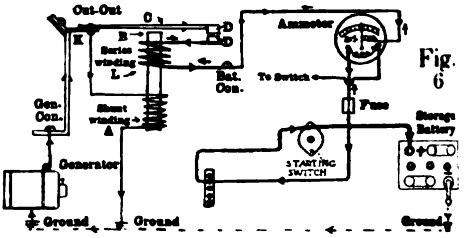


Fig. 3—Circuit wiring diagram. The "cut-out" is now mounted on the generator.

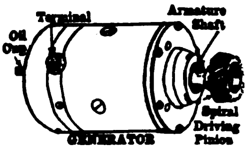


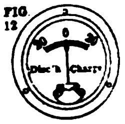
*Cut-Out Action.

When engine is started and running slow, current flow from generator begins to build up magnetic strength in iron core (B), through fine wire winding (A). Note connection to battery is open at (D).

When car speed reaches 10 m.p.h. on high gear, generator current is then strong enough for (A) to magnetize (B), and blade (C) is drawn to (B), which closes contact points (D). Generator voltage is then 6.8 volts, or slightly more than battery (battery is 6 volts). Therefore generator **charges battery** with current passing through the coarse wire winding (L), through ammeter to battery. Generator current is now passing through (L) & (A) in **same direction.**

When engine slows down less than 10 m.p.h. generator voltage is then less than the battery voltage, therefore battery current begins to flow, or discharge in opposite direction (see outside arrows), through winding (L), and this is why it is called a "reverse current" cut-out. This action opposes generator current passing through (A), which is weak, with result that core (B) loses its magnetism, or is demagnetized and releases blade (C), through tension of spring (K), thus opening circuit between generator and battery. This action is repeated over and over as engine speeds up and slows down.





Ammeter

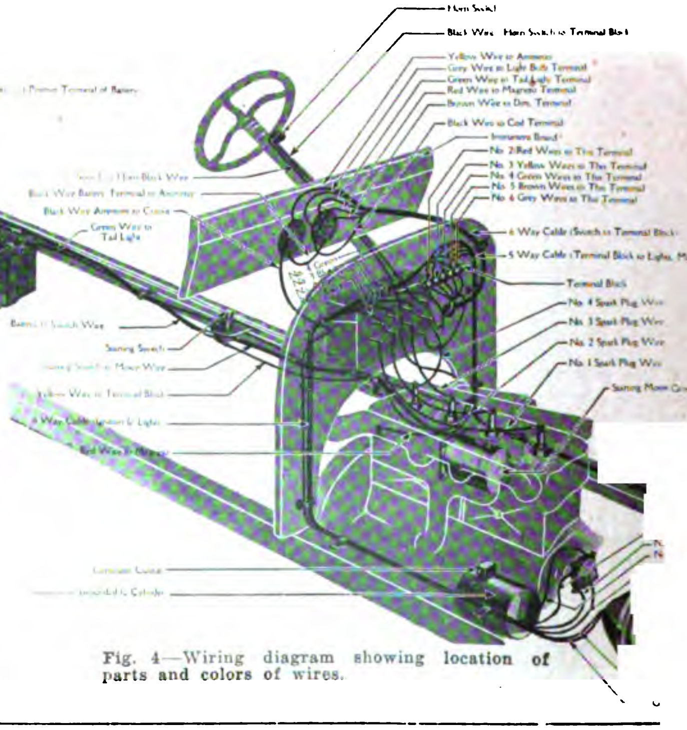
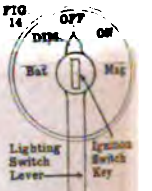

Horn Switch
Black Wire Horn Switch to Terminal Block
Yellow Wire to Ammeter
Grey Wire to Light Bulb Terminal
Green Wire to Tail Light Terminal
Red Wire to Magneto Terminal
Brown Wire to Dim Terminal
Black Wire to Coil Terminal
Instrument Board
No. 2 Red Wire to This Terminal
No. 3 Yellow Wire to This Terminal
No. 4 Green Wire to This Terminal
No. 5 Brown Wire to This Terminal
No. 6 Grey Wire to This Terminal
6 Way Cable (Switch to Terminal Block)
5 Way Cable (Terminal Block to Lights, Mag & Fuse Switch)
Terminal Block
No. 4 Spark Plug Wire
No. 3 Spark Plug Wire
No. 2 Spark Plug Wire
No. 1 Spark Plug Wire
Tail Light
Battery
Green Wire to Tail Light
Starting Switch

Fig. 4—Wiring diagram showing location of parts and colors of wires.



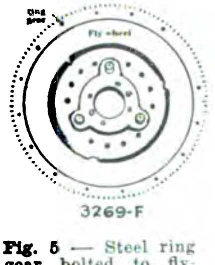


Fig. 5 — Steel ring gear bolted to fly-wheel for starting motor — see page 864A.

NO. 397A—Electric System on Ford Enclosed Cars.

864A and a description of another cut-out which is similar on page 344. This

Next inspect the wiring from the generator through the meter, to the battery for a break in the insulation that would result in a short-circuit.

Lighting System.

The lighting system consists of two 2-bulb headlights and a tail light operated by a combination lighting and ignition switch located on the instrument board. The large or headlight bulbs are of 6-8 volt, 17 candle-power type, 2½ amp. The small or dimmer bulbs are of 6-8 volt, two candle-power type, .942 amp. The small bulb is also used in the tail light.

All of the lamps are connected in parallel so that the burning out or removal of any one of them will not affect the other. Current for the lamps is supplied by the battery.

Do not connect the lights to the magneto as it will result in burning out the bulbs and might discharge the magnets. Illustration figs. 3, 4, show the different circuits and the course of the current, also the **ignition switch,** which is a key and the **lighting switch,** which is a lever.

How To Remove Starter.

When removing the starter to replace transmission bands, or for any other reason, first remove the engine pan on the left hand side of the engine and with a screw-driver remove the four small screws holding the shaft cover to the transmission cover. Upon removing cover and gasket, turn the Bendix drive shaft around so that the set screw on the end of the shaft, as in fig. 2, is in the position shown. Immediately under the set screw is placed a lock washer, designed with lips or extensions opposite each other on the outside diameter. One of these is turned against the collar and the other is turned up against the side of the screw head. Bend back the lip which has been forced against the screw and remove the set screw. As the lock washer will no doubt be broken or weakened in removing the starter, a new one must be used when replacing it. These washers may be obtained from the nearest branch.

Next, pull the Bendix assembly out of the housing, being careful that the small key is not misplaced or lost. Remove the four screws which hold the starter housing to the transmission cover, and pull out the starter, taking same down through the chassis—this is why it was necessary to remove the engine pan.

Extreme care should be used in removing the Bendix drive and other parts that none are misplaced nor lost and that they are replaced in their former position.

In replacing the starter, be sure that the terminal connection is placed at the top. If the car is to be operated with the starter removed, be sure to put the transmission cover plates in position. These plates may also be obtained from the nearest branch.

How To Remove Generator.

If it is found necessary to remove the generator, first take out the three cap screws holding it to the front end cover and by placing the point of a screw-driver between the generator and front end cover, the generator may be forced off the engine nbly. Always start at the top of the genera- and force it backward and downward at the time.

es may be obtained from the nearest branch to e over the time gear if the car is to be oper- the generator removed.

w To Operate Engine With Generator Removed.

reason the engine is run with the rator disconnected from the battery, as block test, or when battery has been re- d for repair or recharging, be sure that generator is grounded to engine by run- wire from the terminal on generator to one of the valve cover stud nuts. A piece of wire $\frac{1}{8}$" or more in diameter may be used for this purpose. Be sure that the connections at both ends of the wire are tight. Failure to do this when running the engine with the generator disconnected from the battery will result in serious injury to the generator.

Care of Battery.*

The Ford Starting System uses a 6-volt 13-plate "Exide" battery, type 3-XC-13-1. The care of the battery in service is summed up in the following rules:

1. **Add nothing but pure water to the cells and do it often enough to keep the plates covered at all times.** Distilled water, melted artificial ice or rain water collected in clean receptacles is recommended. In cold weather add water only just before running the engine so that the charging may mix the water and the electrolyte and freezing of the water be avoided.
2. **Take frequent hydrometer readings to make sure that the generator is keeping the battery charged.** To take reading, remove filler cap of cell, insert end of hydrometer syringe in filler opening, squeeze bulb and release, drawing up enough liquid to float hydrometer bulb free in the liquid. The reading of the scale at the surface of the liquid when hydrometer is floating is the specific gravity (density) of the electrolyte. A **fully charged** battery will show a reading of 1.275 to 1.300. A battery **half charged** will show a reading of 1.225 to 1.250. A completely **discharged battery** will show a reading of 1.200 or less.

   When taking hydrometer readings remove the filler cap from only one cell at a time and be sure to return electrolyte to the cell from which it was taken. Then replace and tighten the filler cap.

   Hydrometer tests taken imediately after filling with water and before water has become thoroughly mixed with the electrolyte will not show the true condition of the battery.
3. **If hydrometer reading shows battery less than half charged it should be recharged.** Continued operation in a less than half charged condition is injurious to the battery, somewhat as running in a soft or deflated condition is injurious to a tire.
4. **Keep the filler caps in place and screwed tight**—a half turn tightens them. Keep battery connections tight and clean. A coating of heavy oil or vaseline will protect the connectors from corrosion. Keep battery firmly secured in place. If hold-downs are loose, battery will shift about in compartment and result in loose connections, broken cells or other troubles.

Electric Horn.

The electric horn button is located on the steering post. See wiring diagram for connections.

Cut-Out.

The cut-out is located on the generator. The principle of this cut-out is explained on page 864B.

Fuse.

The fuse which was on some of the first Ford Electric Systems has been discontinued.

Changes on Engine.

The following changes have been made on engines of enclosed cars, to accommodate the starter motor and generator.

Transmission cover changed to take starter. Ford No. is 3376B.

Cylinder block changed. Ford No. 3000C.

Cylinder block front cover, changed. Ford No. 3009C.

Cylinder block front cover liner. Ford No. 3018.

Timing gear cover. Ford No. 3017.

Flywheel with ring gear. Ford No. 3269F.

The ring gear bolts to flywheel and has teeth cut in it to take starting motor gear. See fig. 6.

Price of Coupe and Sedan.

Price includes the electric system, demountable plain clincher rims of 5 lugs and tires all 30x3½, and an extra rim or carrier. F. O. B. Ford Factory at Detroit and without war tax. Coupe $750; Sedan $875.

---

pages 455, 557, 458.

Cadmium Test of a Storage Battery.

Why Necessary.

The condition of a storage battery is usually ascertained by taking a specific gravity reading of the electrolyte, with a hydrometer as per page 450. A reading of 1,275 to 1,300 being usually considered as indicating a fully charged cell. While specific gravity readings with a hydrometer should always be made, yet they should not be relied upon entirely.

For instance, a battery which gave entirely satisfactory hydrometer tests, may show a rapid drop in voltage when in use, yet this condition could not be foretold by hydrometer readings alone, because the hydrometer readings would not tell us the condition of either the positive or negative plates, and it is their condition which determine the amount of energy in any battery.

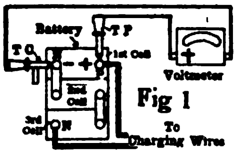


Fig 1

Fig. 1. Testing the voltage of all cells of battery, when battery is on charge and preliminary to taking a cadmium test.

We may also take a voltage reading of the entire battery per fig. 1, while current is being drawn from the battery which gave satisfactory hydrometer readings. This would tell us if the plates were not in good condition, but it would not tell us **which set of plates** was at fault, because the voltage reading includes all positive and negative plates, as per fig. 1.

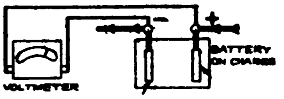


Fig. 1A. Testing one cell of battery when on charge and preliminary to cadmium test.

If we took a voltage reading of one cell per fig. 1A, while battery is on charge, you can readily see that the test includes both positive and negative plates. Suppose the battery will not take a full charge, which set of plates is defective; the positive or negative?

Therefore, to determine the condition of the positive and negative plates separately, we must make a test between each set of plates and some neutral substance. Theoretically, a number of substances could be used for the neutral substance, but for practical reasons cadmium is used.

*The Cadmium Outfit.

Cadmium is a metal, it looks like zinc, but is pure, because there is no other substance mixed with it.

A cadmium testing outfit consists of two copper test points, one of which has a stick of cadmium, about 3½" long and ¼" di., riveted to it, as per fig. 2, and a special reading voltmeter.

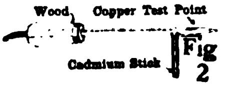


Fig 2

Fig. 2. The test-point, with the cadmium stick riveted to it. The cadmium is the part which is inserted in the electrolyte.

The cadmium test can be made while a battery is on charge or when it is being discharged. As a rule, the test is made only near, or at the end of a charge, in order to determine if both positive and negative groups are taking the charge properly.

The Voltmeter.

Any accurate voltmeter can be used, which gives readings up to 2.5 volts in divisions of .05 volt. The test point (TC, fig. 4) is connected to right hand terminal of the voltmeter and the test point (TC) with the cadmium on it is connected to the + terminal of voltmeter.

FIG. 3

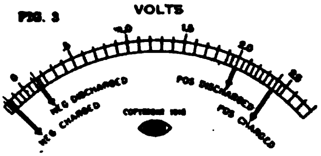


Fig. 3. Scale of dial on the cadmium test volt meter—one-half actual size.

As an example, however, we will use the face dial of a special made voltmeter manufactured especially for this purpose, which is one-half actual size, called the Ambu Cadmium Voltmeter, see fig. 3.

How To Test a Battery on Charge.

The charging current must be passing through the battery at normal rate when the test is made, and needle of voltmeter should be exactly on zero—this can be set with the zero adjustment. Then proceed as follows:

Measure the voltage of one cell, by holding one of the test points on the positive (+) and the other on the negative terminal (—), of the cell, as per fig. 1A.

If the cell is fully charged, the reading of voltmeter will be from 2.5 to 2.6 volts, depending on the age of the battery; a new battery giving a higher reading than an old one. (see also pages 410, 416.)

Cadmium Test of Positive Plates When on Charge.

Test the positive plates of one cell, by inserting the cadmium rod on test point (TC) in the electrolyte at vent (V) of cell, per fig. 4, being sure **the cadmium does not touch the top of plates** (a rubber tip at end of cadmium **stick is provided on** the Ambu set, to avoid **touching.**)

Fig 4

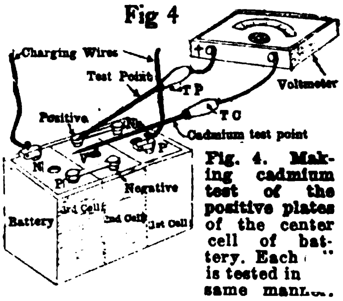


Fig. 4. Making cadmium test of the positive plates of the center cell of battery. Each is tested in same man

Allow the cadmium to remain in the electrolyte for several minutes, until electrolyte has no further action on the cadmium. Then [illegible] of the c test point (TP) on the **positive** cell

If positive plates are fully cha voltmeter reading will be, to the line O, fig. 3, at least 2.35 and may or even 2.50, if battery is new. Shoul ing be **less** than these, then the **po** **are not fully charged.**

Continue the charge, and plates will not then give a **reading of** 2.35 then **positive plates are**

---

*This outfit can be obtained of A. L. Dyke, Elec. Dept., see page 864-I.

Cadmium Test of Negative Plates When On Charge.

Test the negative plates, by placing the test point (TP) on the negative terminal of the cell, per fig. 5.

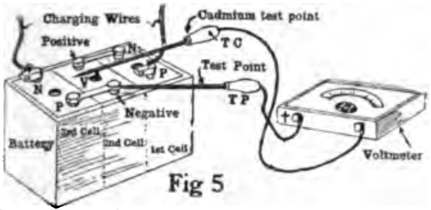


Fig. 5. Making cadmium test of the negative plates of the center cell of battery. Each cell is tested in same manner.

If the negative plates are fully charged, the voltmeter reading will be from—0.175 to —0.2, that is, the needle will move to the **left** of "O" line on the scale, fig. 3.

Should the reading be very nearly zero, or if the needle swings to the **right** of the "O" line (fig. 3), the **negative plates are not fully charged.**

Continue the charge, and if the negative plates will not give a reading of from 0.175 to 0.2 volts to the **left** of the "O" line on the scale, then the **negative plates are defective.**

Test the other cells of battery in the **same** manner.

The difference between the positive—to—cadmium readings and negative—to—cadmium reading is 2.595, the voltage of a fully charged cell while on charge.

Readings On Scale of Voltmeter.

This special voltmeter, fig. 3, page 364-D, has the "O" line near the left end of scale. The scale is marked especially for cadmium tests.

To the left of the "O" line is a red line marked "NEG. CHARGED." This line indicates the reading of —0.175 which should be obtained when testing **new** negative plates which are **fully charged,** that is, when making a cadmium test on the negatives, the pointer should move to this red line. If the pointer does not move as far as the red line, the negatives are not fully charged.

Similarly, there is a red line at +0.175 marked "NEG. DISCHARGED," at +2.00 marked "POS. DISCHARGED," and at +2.42 marked "POS. CHARGED."

Old cells will give readings which are not quite as high as those indicated by red lines.

Table of Readings
below give voltmeter and cadmium readings taken at hourly intervals on a battery during time it was being charged at a normal rate. Any healthy battery should not depart widely from these readings.

Hours on charge	Reading across cell-volts	Reading positive pole to cadmium-volts	Reading negative pole to cadmium-volts
0	2.10	2.25	+.15
1	2.17	2.27	+.10
2	2.19	2.28	+.09
3	2.21	2.29	+.08
4	2.23	2.31	+.08
5	2.24	2.32	+.08
6	2.25	2.33	+.08
7	2.30	2.35	+.05
8	2.48	2.43	—.05
9	2.60	2.50	—.10

How to Test a Battery on Discharge.

The battery should be discharging for this purpose, it may be connected to a number of lamps which will draw about 5 amperes from it.

Test the positive plates on discharge, in the same manner as before mentioned when testing a battery on charge.

If positive plates are discharged, they will give a reading of 2.00 to 2.05 volts.

If the hydrometer test shows that battery is discharged, and the positive plates give a reading greater than 2.05, they are not discharging properly or else there is an incorrect amount of acid in the electrolyte.

Test the negative plates on discharge, in the same manner as before mentioned when testing a battery on charge.

If the negative plates are discharged, they will give a reading of about 0.175 to the **right** of the "O" line on the **scale.**

If the negative gives a reading between "O" and 0.175, but less than 0.175 they are not discharging properly.

What To Do If Cadmium Tests Show Defective Plates.

Usually, when the cadmium tests show that either positive or negative plates are not taking a charge satisfactorily, it is only necessary to continue the charge until the proper readings are obtained.

If the specific gravity of the cell is not from 1.275 to 1.300 when the cadmium tests show that both positives and negatives are
y charged, some of the electrolyte should
removed and replaced by pure distilled
er, or 1.400 specific gravity electrolyte,
he case may require.

the specific gravity reading is too high,
he distilled water.

the specific gravity reading is too low,
.400 specific gravity electrolyte should
added until the gravity is from 1.275 to
).

ould the specific gravity reading indicate that a cell is fully charged, that is, if the hydrometer tests give readings from 1.275 to 1.300, but the cadmium tests indicate that both sets of plates are not fully charged, continue the charge to see if the proper cadmium readings can be obtained.

If it is impossible to obtain the proper cadmium readings on one or both sets of plates, these plates are defective.

If the operation of the battery on discharge is satisfactory, the only effect of the defective plates will be to cause the battery to lose its charge more quickly than normal, and thus require frequent charging.

If the operation of the battery on discharge is not satisfactory, however, the battery should be opened, and the defective plates repaired, or new plates put in.

Pointers to Remember When Making Cadmium Tests.

emember that current must be passing
hrough the battery when you **make the**
admium tests.

(2) **The temperature of the electrolyte should** be about 70° F. when cadmium tests are made, if accurate results are desired.

(3) **Do not send out a new battery unless the** hydrometer readings are from 1.275 to 1.300, until the positive-to-cadmium tests give at least 2.40 volts, and the negatives-to-cadmium test give about—0.175 volts.

(4) **Do not scrape off the coating of sulphate** which forms on the cadmium.

(5) **Do not allow the cadmium to become dry** after you have made tests with it. Keep the cadmium immersed in a glass of pure distilled water, or dilute electrolyte.

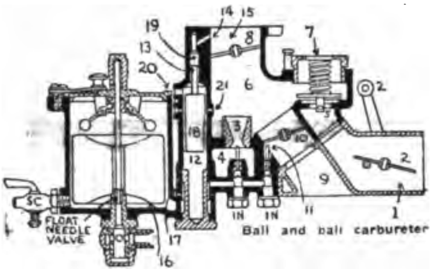
(6) **Be sure to get good contact** when you hold the sticker on the battery terminal. Bear down on the handle so that the point of the sticker digs down into the terminal.

(7) **If both positive-to-cadmium and negative-to-cadmium readings are very nearly zero,** the cell is short circuited and must be inspected for excessive sediment, or defective separators.

(8) **The end of the cadmium rod must not be allowed to touch the tops of either set of plates,** as this would give worthless readings.

Ball and Ball Carburetor.

First or primary stage, when starting and usual running conditions: 1 is the hot air passage of the primary carburetor containing the choke valve 2. 3 is the primary venturi throat connecting the hot air passage with the mixing chamber 6, and containing the gasoline jet 4. 5 is another fixed air regulating orifice connecting the hot air passage 1 with the mixing chamber 6, and provided with a spring-opposed idling valve 7 arranged to control the air when small quantities only are being used. 8 is a throttle valve of the usual type. The parts so far described constitute the first stage.



Ball and Ball Carburetor, as used on the Peerless, Studebaker, King, Mercer, Oldsmobile.

Second stage, or when throttle is wide open for full power: 9 is an air passage leading from the external air to the mixing chamber 6, and it contains the butterfly valve 10, arranged to control the flow of air through this passage. 11 is a gasoline jet arranged to discharge gasoline into the passage 9, when the valve 10 is opened, causing the gasoline jet 11 to be acted on by the suction of the mixing chamber 6. The air passage 9, with the gasoline jet 11, constitutes the second stage which is brought into action by opening the butterfly valve 10. A connection between the butterfly valve 10 and the throttle valve 8 (not shown) is so arranged that when the throttle valve 8 is nearly wide open, the further opening of this valve throws the valve 10 wide open. At all other times, the valve 10 is held closed by a spring (not shown).

From the foregoing description, it will be seen that under all the usual running conditions of the engine, the primary carburetor, or first stage only, is in service, and the second stage comes into service only when the throttle is thrown wide open for full power. The effect of this arrangement will be described further on.

Pick-up device; continuing the description, 12 is a cylindrical chamber with an extension 13 of reduced diameter connected by the passage 14 with the chamber 15, above the throttle valve. The chamber 12 is connected with the float chamber 16 by means of the restricted passage 17, so that the gasoline at all times in this chamber 12 stands on a level with the level in the float chamber. 18 is a loosely fitting plunger with an extension 19 on its upper end, forming a piston in the chamber 13. An atmospheric opening, 20, is located in the wall of chamber, 12, and a passage, 21, leads from chamber, 12, to the mixing chamber, 6, through which passage, air is constantly drawn into the mixing chamber.

Operation of the pick-up device: it will be seen that in the operation of the engine, when the throttle is closed, the vacuum of the manifold acting on the piston, 19, causes the plunger, 18, to rise to its upper position, thus closing the passage to the chamber, 15. The space below the plunger, 18, is now filled with gasoline from the float chamber, and the mechanism is ready for action.

The opening of the throttle, 8, breaks the vacuum in chamber, 15 and releases the plunger, 18, which falls and displaces the gasoline underneath the plunger, causing it to flow into the space above the plunger, where it is quickly discharged through the passage, 21, to the mixing chamber, thus augmenting the normal supply of gasoline and causing a rich mixture to momentarily enter the cylinder. This develops a strong pick-up.

Adjustments: There are no adjustments after size of jets are determined.

Air regulation: Amount of air is controlled by valve (2) which is operated by the choke rod handle on dash or steering post. For **cold weather** this valve (2) should be closed to draw in a rich mixture. Immediately engine starts push it down part of way until engine is warm, then close entirely. Don't open throttle at all when (2) is closed and don't run with (2) closed any more than possible.

Troubles: Dirt under float valve will cause dripping; unscrew cap over float needle valve and give it a few turns. Water or dirt may lodge in small openings and this is indicated by popping and missing. Close valve on gravity tank, remove four nuts at bottom and clean jets.

*WIRING MANUAL—All Blue Prints.

With this Wiring Manual you will be able to quickly locate and repair faulty circuits, generators, starting motors, batteries, coils, controllers, switches, etc., relating to all electric systems on all cars fr

There are 680 pages, **7½x11 inch,** showing the wiring diagra 550 cars and 175 internal diagram 700 diagrams in all—and blue pr includes instructions on how to tes pair batteries, coils, regulat tors, generators, etc.

Hundreds of cars must be **of oil soaked and worn out insulation.** job is difficult unless a diagram is These diagrams are **easy t**

Price ....

(If you wish more information send for

*Supplied by A. L. Dyke, Publisher, Granite Bldg., St. Louis, Mo.

Model	Engine	Ignition	Starting Lighting	WB	Tires	Rims	2-Pass.	5-Pass.	7-Pass.	Sedan
..8					33x3½	SS	...	$1195	...	$1695
AMERI(										
B	-8				32x4	SS	$1835	1765	$1865	....
AMERICAN BEA										
	6-3½x..		G..	.	33x4½	SS	...	2000	....	.
ANDERSON										
400-A-E	6-3¼x4½	Conn	Wsths	..0	33x4	SS	....	1675	1750	2550
ANNIVERSARY										
	8-3¼x5	Remy	Bijur	130	33x4 34x4½	SS	†4000	....	4000	...
APPERSON										
8-20	8-3¼x5	Remy	Bijur	130	33x4 34x4½	SS	2625	†2575	2625	3700
AUBURN										
6-39-H-K	6-3¼x4½	Remy	Remy	120	33x4	SS	†1595	1595	...	....
BELL										
	4-3¾x4½	A.Kent	Dyneto	114	31x4	QD	1145	1145	.	...
BIDDLE										
H	4-3¾x5½	Eismann	G & D	121	32x4	QD	3000	*3100	†2750	4400
BRISCOE										
B4-24	4-3⅛x5⅛	Conn	A-Lite	104	30x3½	C	885	885	..	..
BUICK										
H-6-44-47	6-3⅜x4½	Delco	Delco	118	33x4	SS	1495	1495	....	2195
H-6-49-50	6-3⅜x4½	Delco	*Delco	124	34x4½	SS	...	....	1785	2585
CADILLAC										
57	8-3⅛x5⅛	Delco	Delco	125 132	35x5	SS	3220 ...	†3220 .	3220 ..	4090 4340
CASE										
U	6-3½x5¼	Wsths	Wsths	125	35x4½	SS	†2100	..	2100	..
CHALMERS										
6-30	6-3¼x4½	Remy	A-Lite	117 122	32x4 34x4	SS	1565 ...	1565	 1615	2250 ...
CHANDLER										
	6-3½x5	Bosch	Wsths	123	33x4	SS	†1795	....	1795	....
CHEVROLET					34x4½		....	....	....	2695
490	4-3 11/16x4	Remy	A-Lite	102	30x3½	C	715	735	....	$1185
FB	4-3 11/16x5¼	Remy	A-Lite	110	33x4	SS	1110	1135	....	1685
D	8-3⅜x4	Remy	A-Lite	120	34x4	SS	....	1585	....	...
COLE										
870	8-3½x4½	Delco	Delco	127	33x5	SS	2595	†2595	2595	3995
COLUMBIA										
D-C&CS	6-3¼x4½	A.Kent	W.Lard	115	32x4	SS	†1745	1600	....	2445
COMET										
C-51	3½x5¼	Delco	Dyneto	125	33x4	SS	....	1685	....	....
CROW-ELKHART										
CE-36	4-3½x5	Conn	Dyneto	115	32x3½	SS	1095	1095	†1155	1445
CE-46	6-3½x5	Conn	Dyneto	116	33x4	SS	1295	1295	†1355	....
CUNNINGHAM										
V-3	8-3¾x5	Delco	Wsths	132	35x5	SS	†4250	*4750	4250	....
DANIELS										
B	8-3½x5	Wsths	Wsths	127	34x4½	QDR	3750	3750	3750	5500
DAVIS										
51-54	6-3¼x4½	Delco	Delco	120	33x4	SS	....	†1750	1695	2395
DISPATCH										
G	4-3¾x5	Bosch	USL	120	34x4	SS	‡1250	†1290	....	....
DIXIE FLYER										
H-S-50	4-3¾x5	Conn	Dyneto	112	32x4	SS	. . .	1365	....	....
DODGE BROTHERS										
	4-3⅞x4½	Own	N.E.	114	32x3½	SS	1085	1085	....	1750
DORRIS										
6-80	6-4 x5	Bosch	Wsths	132	35x5	SS	....	3750	3750	4615
DORT										
11	4-3⅝x5	Conn	Wsths	105½	30x3½	QD	†925	925	....	1355
ELCAR										
D.F.	4-3½x5	A.Kent	Dyneto	116	32x3½	SS	....	1175	†1175	1725
	6-3¼x4½	A.Kent	Dyneto	116	33x4	SS	....	1375	†1375	1895
ELGIN										
H	6-3¼x4½	Wagner	Wagner	118	33x4	SS	....	1395	....	1950
ESSEX										
A	4-3⅜x5	Delco	Delco	108½	32x4	SS	....	1395	....	2250
FORD										
FRANKLIN										
9B	6-3¼x4	A.Kent	Dyneto	115	33x4½	SS	$3400	2450	†2450	$3350
GRANT										
G	6-3 x4½	Remy	Wagner	114	32x3½		1120	1120	....	1645
HANSON	3½x4½	.....	....	119	32x4	SS	....	1685	....	....
HARROUN										
A-1	4-3¾x5½	A.Kent	Remy	106	30x3½	...	1095	995	....	....
HAYNES										
45	6-3½x5	Remy	L-N	127	34x4½	SS	†2485	....	2485	3350
46	12-2¾x5	Delco	L-N	127	34x4½	SS	....	†3250	3250	4000
HOLLIER										
206	6 3¼x4½	Remy	Splitdorf	114	32x4	SS	....	1785	....	....
HOLMES										
	6-3¼x4½	Eiseman	Dyneto	126	34x4½	SS	....	....	3900	3900
HUDSON										
Super-6	6-3½x5	Delco	Delco	125½	35x4½	SS	....	†2075	1975	2775
HUPMOBILE										
R	4-3¼x5½	A.Kent	Wsths Remy	112	32x4	..	1335	1335	....	2135
JONES										
28	6-3¼x5¼	Remy	Wsths	126	34x4	SS	2100	†2350	2100	....
JORDAN										
J-60	6-3¼x5¼	Delco	Bijur	127	32x4½	SS	....	†2475	2475	3600
KING										
G	8-3 x5	A.Kent	Bijur	120	34x4	SS	2550	2850	2150	3100
KISSEL KAR										
Custom Built	6-3⅜x5½	Remy	Remy	124	32x4½	SS	....	....	....	....
KLINE KAR										
6-42-H	6-3¼x4½	Conn	Wsths	121	33x4	...	1865	1865	†1865	2590
LEXINGTON										
R-19	6-3¼x4½	Conn	Wsths	122	34x4	SS	....	1785	1785	2850
LIBERTY										
10-B	6-3¼x4½	A.Kent	Wagner	115	32x4	SS	1570	†1720	1570	2640
LOCOMOBILE										
48	6-4½x5½	Berling	Wsths	142	35x5	QD	†6700	*6600	6600	....
MADISON										
	6-3¼x5	Remy	Remy	115	33x4	SS	....	1550	....	...
MAIBOHM										
B	6-3¼x4½	A.Kent	Wagner	116	32x3½	SS	....	1290	....	1890
MARMON										
34	6-3¾x5¼	Bosch	Bijur	136	32x4½	QD	†3950	3900	3950	5750
MAXWELL										
25	4-3⅝x4½	A.Kent	Simms	109	30x3½	C	895	895	....	1565
McFARLAN										
	6-4½x6	Bosch	Wsths	136	35x5	QD	4300	†4500	4300	5600
MERCER										
Series 4	4-3¾x6¾	Berling	Wsths	132	32x4½	SS	4350	†4500	*4500	....
MITCHELL										
E-40	6-3¼x5	Remy	Remy	120	33x4	SS	‡1475	1475	....	2175
E-42	6-3½x5	Remy	Remy	127	34x4	SS	....	....	1675	....
MOLINE-KNIGHT										
L	4-3¾x5	Conn	A-Lite	118	34x4	SS	†2000	2000	......	..
G	4-4 x6	Conn	A-Lite	122	35x4½	SS	†2500	....	2500	....
MONITOR	6-3¼x4½	Dyneto	....	117	33x4	. .	1475	....	†1475	....
MONROE	4-3⅛x4½	A-Lite	A-Lite	115	32x3½	SS	1195	1195	....	....
MOON										
6	3¼x4½	Delco	Delco	118	32x4	SS	....	1685	....	....
6-66-19	6-3½x5¼	Delco	Delco	125	35x4½	SS	†2500	....	2300	3250
MOORE	4-3¾x4½	Conn	A-Lite	106	30x3½	...	....	895	....	....
MURRAY										
	8-3¼x5	Dixie	Wsths	128	34x4½	..	2800	2800	2800	
NASH										
682				127	34x4½	SS			1640	
681-6	6-3¼x5	Delco	Delco	121	33x4	SS	†1490	1490	†1640	
684					34x4½	SS	.....	....	....	2250
NATIONAL										
Six	6-3½x5¼	Delco	Wsths	128	34x4½	QDR	†2450	†2450	2450	3120
Twelve	12-2¾x4¾	Delco	Bijur	128	34x4½	QDR	†3050	†3050	3050	3720
NELSON										
	4-3¼x4¾	Bosch	U.S.L.	104	32x4	SS	1200	†1400	....	1800
NORWALK										
OAKLAND										
34-B	6-2 13/16x4¾	Remy	Remy	112	32x4	SS	‡1075	1075	....	1650
OLDSMOBILE										
45-A	8-2⅞x4¾	Delco	Delco	120	34x4	SS	...	$†1700	$1700	....
37-A	6-2 13/16x4¾	Remy	Remy	112	32x4	SS	$†1295	1295	....	1895
OLYMPIAN										
45	4-3¾x4½	Conn	A-Lite	112	32x3½	...	1240	1240	....	....
OVERLAND										
90	4-3¾x5	Conn	A-Lite	106	31x4	C	....	985	....	1495
OWEN-MAGNETIC										
W-42	6-4 x5½	Bosch	Own	142	35x5	SS	....	....	5500	6500
PACKARD										
3-35				136					5150	....
3-25	12-3 x5	Delco	Bijur	128	35x5	QD	....	4800	4800	....
PAIGE										
6-40	6-3½x5¼	Remy	G & D	117	33x4	SS	‡1555	1555	....	....
6-55	6-3¾x5¼	Remy	Remy	127	35x4½	SS	....	†2165	2060.	2950
PATERSON										
6-46	6-3¼x4½	Delco	Delco	120	32x4	C	†1595	1595	1625	2800
PEERLESS										
56	8-3¼x5	A.Kent	A-Lite	125	34x4½	SS	†2760	....	2760	3530
PIERCE-ARROW										
B-5	6-4½x5½	Bosch	Wsths	142	35x5	QD	6400	6400	6500	....
PILOT										
6-45	6-3½x5	Delco	Delco	120	32x4	SS	†1600	1550	....	2350
PREMIER										
6-C	6-3⅝x5½	Delco	Delco	125½	32x4½	SS	....	†2585	2585	3585
REO										
	4-4⅛x4½	Remy	Remy	120	34x4	SS	1395	1395	....	2175
REVERE										
	4-4⅛x6	Bosch	Wsths	131	32x4½	SS	3850	†3850	3850	....
ROAMER										
C-6-54	6-3½x5¼	Bosch	Bijur	128	32x4	SS	2675	†2575	2775	3450
SAXON										
Y-18	6-2¾x4½	Remy	Wagner	112	32x3½	SS	†1195	1195	....	....
SAYERS										
SIX-42	6-3¼x4½	Delco	Delco	118	32x4	...	....	1695	...	....
SCRIPPS-BOOTH										
Six-39	6-2 13/16x4¾	Remy	Remy	112	32x4	SS	‡1295	1295	....	1985
SENECA										
	4-3¼x4½	Remy	Remy	108	30x3½	C	....	990	....	....
SINGER										
19	6-4 x5½	Bosch	Wsths	039	33x5	SS	5000	†5000	5000	7200
STANDARD										
H	8-3¼x5	Dixie	Wsths	127	34x4½	SS	2750	†2750	2750	3800
STANLEY										
Steamer	2-4 x5	......	....	130	35x4½	SS	....	....	3450	4950
STEARNS										
SKL4	4-3¾x5⅝	Remy	Remy	125	34x4½	SS	†2250	2250	2475	3750
STEPHENS										
Salient Six	6-3¼x4½	A-Lite	A-Lite	122	32x4	SS	1775	*1850	†1775	....
STUDEBAKER										
SH-4-40	4-3⅞x5	Remy	Wagner	112	32x3½	SS	....	1225	....	1785
EH-6-50	6-3⅞x5	Remy	Wagner	109	32x4	SS	1585	1585	†1585	2385
E-G-6	6-3⅞x5	Remy	Wagner	126	33x4½	...	....	....	1985	....
STUTZ										
G	4-4⅜x6	Delco	Remy	120 130	32x4½	SS	2750	†2850	*2850	....
TEMPLAR										
A-445	4-3⅝x5½	Remy	Remy	118	32x4	SS	†2385	2185	....	3285
VELIE										
38	6-3¼x4½	Remy	Remy	114½	32x4	SS	1525	1525	†1525	....
39	6-3½x5¼	Remy	Remy	124	33x4½	SS	...	†2035	1910	2085
WESTCOTT										
A-48	6-3½x5¼	Delco	Delco	125	32x4½	SS	....	2590	2590	3190
A-38	6-3¼x4½	Delco	Delco	118	33x4	SS	...	1775	‡2490	2790
WILLYS-KNIGHT										
88-4	4-4⅛x4½	Conn	A-Lite	121	34x4½	SS	....	....	1725	2750
89	6-3⅝x5⅛	Conn	A-Lite	120	33x4½	SS	....	....	1625	..
WINTON										
22	6-4½x5½	Bosch	Bijur	138	35x5	QD	4350	4350	4350	5600

[illegible] †4-passenger ‡3-passenger.

RT NO. 397-B—Specifications of 1919 Cars. See pages 543 to 546 for 1918.

e 546 for meaning of all abbreviations above except "C," which means "clincher" tires. The F
are 30x3½ rear and 30x3 front. (Motor World.)

WESTON DIRECT CURRENT VOLT AND AMMETERS.

The most profitable work of Automobile Repairing is that of electric work. After studying the subjects of the different electric systems in this book, and the principle and **construction** of the Weston meter as shown on page 414, then diagnosing troubles page 416, and **tests on** pages 402, 403, 406, 410, 418, 424, anyone ought to be able to diagnose and remedy **almost any** electric trouble—if equipped with the proper **Testing Instruments** and the **Wiring Manual.**

Weston Model 280 Service Station Combination Volt-Ammeter.

This instrument (fig. 1) is the instrument used as an example on pages 402, 403, 406, 410, 416, and will test every part of the automobile electric system, from current consumed by starting motor, to testing individual windings on generator armatures. The instrument is fully explained on page 414.

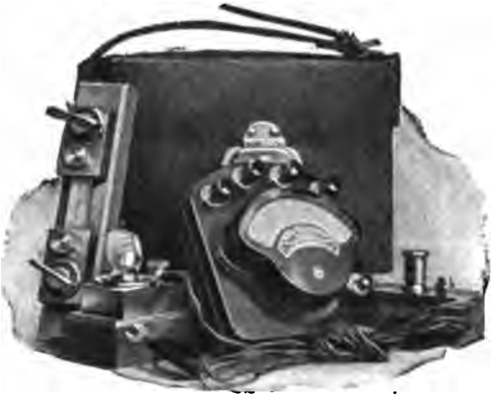


Fig. 1—Weston Model 280 Combination Volt-ammeter with case, three shunts and cables.

Ranges of readings are: 30 volts, 3 volts and .1 volt (100 milli-volt), 300 amperes, **30** amperes and 3 amperes.

The 30 volt range is useful for determining the voltage of generator or battery, per page 410 and tests per pages 416, 406.

The 3 volt range is of service in testing the individual battery cell, per fig. 1, page 416.

The .1 range may be used to test the individual armature windings, per page 402.

The 3 ampere range is of value in testing the current required by single lights.

The 30 ampere range will denote the current required by a complete lighting circuit, or the magnitude of leaks.

The 300 ampere range is useful to determine the starting motor current, per page 410.

The foregoing are merely a few of the tests that may be made with this instrument.

Price, including book of instructions showing how to make practically any electrical test of starting and lighting systems, including 3 shunts, cable, etc. **$32.50**

Leather case, extra **$5.50**

Weston Model 301 Voltmeter and Ammeter—Separate. For Average Garage Work.

If you are unable to invest in the instrument above, then at least equip yourself with the following volt and ammeter.

Model 301 voltmeter with a reading, "0 to 15" volts, for testing cells of a storage battery, per V2, page 410 and figs. 1 and 2, 416 and for testing generator voltage per V1, page 410, 406, etc.

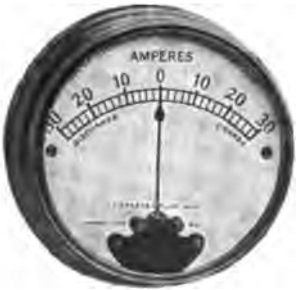


Fig. 2.

Fig. 2: Model 301 ammeter with "0" in center and reads to 30 amperes to the right or left, see page 410.

Model 301 voltmeter reads 0 to 15 volts and is same size and style. Di. 2½".

Model 301 ammeter with a reading, "30-0-30" for testing the amount of current flowing to battery from generator, or **the** quantity of current consumed by all **of the lights** or individual light circuits, **testing** the horn per page 418, igniton, grounds **and short circuits.** The current consumed by **starting motor cannot be tested with this instrument. It will test up to 30 amperes without the use of external shunts. The shunt is inside** of meter up to 30 amperes. **See page 410** for meaning of 30-0-30.

Price of model 301 volt or **ammeter (both** round pattern as shown in fig. 2)......**$6.90**

These instruments (models 301) were primarily designed for use on the dash or cowl of an automobile and the model 301 ammeter is just the instrument to replace "indicators" and defective ammeters, or to place on the dash of a car not equipped with an ammeter.

A Complete Electric Testing Equipment.

If you intend to do all kinds of electric work and specialize on this work, then I would advise that you obtain the **Model 280 Combination Voltammeter** and the **Cadmium** fit, page 864I, and the **Wiring Manual,** 864F. You will then be completely

A Portable Electric Testing Stand.

If however, you wish to make the average tests around a garage, then you can purchase the two models of 301 instruments mentioned above, and mount them on a portable stand and rig up a very serviceable outfit.

Fig. 8, page 864-J, shows a rough ske **how a portable testing stand can be** The illustration is rather exagger will serve the purpose of the idea.

—continued on

Address all orders to A. L. Dyke, Electric Dept., Granite Bldg., St. Louis, Mo.

We repair Magnetos, Generators. Starters, Coils, etc. Send prepaid and we will test out and

—continued from page 864-H.

The cables are flexible insulated wire with test points or clamps on one end and plug connections at the other end, like those used on telephone switchboards.

The plug receptacles can be mounted into the base of the stand and connected as shown, with meters, battery and test lamp, and in this way one set of cables can be used for all tests. A record sheet (R), can be placed on stand with thumb tacks, in order to keep a record of the readings.

An example of how the cables are plugged into different holes for different uses are as follows:

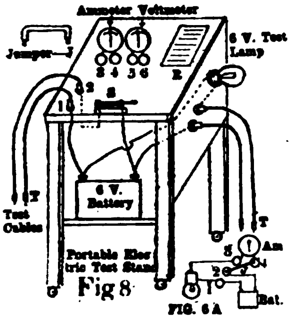


Fig 8

FIG. 8A

To use storage battery for any purpose, as testing a lamp or horn, or to connect to the battery side of a Ford ignition coil to run engine on the battery, while testing magneto, as per page 864J, place cable plugs in 1 and 2 and close switch (S) and use ends of cables.

To test amperage of a lamp bulb or horn; connect jumper (J) from 2 to 4, per fig. 8A. Then place cable plugs in 1 and 3. Touch test points (T) to lamp or horn. Note ammeter will then be in series.

To test generator output. Place cable plugs in 3 and 4 and place meter in series with circuit as is the dash ammeter page 410, or disconnect wire at terminal of generator and connect one test point (T) with generator terminal and other with the wire disconnected. This will place the ammeter in series with the generator circuit.

To test voltage of a generator, per V1, page 410, **or of a batery,** per fig. 1, page 416, or for any other voltage tests; place cable plugs in 5 and 6 holes or receptacles.

Note. It is advisable to place a 30 ampere, glass type fuse between plug receptacle 4, and ammeter, for the purpose of protecting the ammeter from accidental burn-out through overload or otherwise.

Other testing outfits can be added to this portable stand, as the spark plug test outfit, page 710, fig. 17 and page 418 and the battery test outfit, per page 474. In fact there is no limit as to how elaborate one can devise a stand of this kind, and in one shop, the stand is mounted on small steel wheels.

A test lamp outfit, for tests as shown on page 418, 403, 402, is shown mounted on this stand. Note the lamp is in series with the battery. The same cables can be used here.

THE CADMIUM TESTING OUTFIT

For Storage Batteries.

An ordinary voltmeter and a hydrometer will tell you if the battery is charged or discharged and you can also determine with a voltmeter if the plates are in good condition as explained on page 864-D, **but neither the hydrometer or voltmeter will tell you which set of plates are defective.** The **Cadmium test,** in connection with a **special reading voltmeter will tell you instantly.** See pages 864-D and E.

Usually, when a battery shows full charge with a hydrometer or voltmeter, when charging, yet drops or loses its charge quickly when in use, the trouble is with one or more sets of plates, either the "positive" or "negative," in one or more of the cells. In order then, to save disassembling **all** cells to find the defective plates (probabilities are you would not tell accurately even after disassembling) the **Cadmium Test** will tell you **instantly** where the trouble is.

If you propose doing battery repair work, you can turn out better work because you uld never let a battery go out of your e unless the hydrometer readings are n 1.275 to 1.300; until the positive-to- mium tests give at least 2.40 volts, and negatives-to-Cadmium test gives about volts.

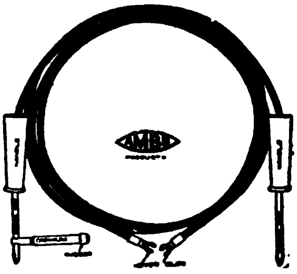


Fig. 1. Cadmium Leads and Test Points.

Fig. 1. The two test points are attached to flexible wire cables or **"Leads."** One of the test points has a piece of cadmium riveted to it. See page 864-D, for explanation of use.

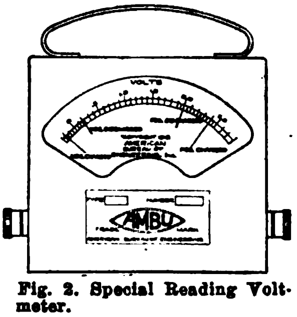


Fig. 2. Special Reading Voltmeter.

Fig. 2. The special reading voltmeter used for making cadmium tests. Note the scale is calibrated showing exactly where needle should be when testing either the positive or negative plates—see page 864D.

Price of Cadmium Outfit.

, **complete outfit,** packed in a convenient case with complete Instructions including Volt-
er and Cadmium Leads with Test Points, per figs. 1 and 2........................$25.00
meter alone, per fig. 2,.. $22.50
nium Leads with Test Points if purchased separately, per fig. 1, only............$ 3.25

ess all orders to A. L. Dyke, Elect. Dept., Granite Bldg., St. Louis, Mo. **We repair Magnetos, Coils, ators and Starting Motors**—send your repairs to us, if you are not equipped.

FORD MAGNETO TESTER.

The Ford magneto generates "alternating" current. An ordinary "direct" current meter as explained on page 864-H and I, will not operate. Therefore a special meter per fig. 6 is designed for testing the Ford magneto.

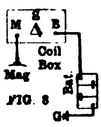


FIG. 8

If the engine will not run at all and the ignition is the fault, an easy way to determine if the cause is due to the magneto, is to connect a storage battery, or five or six dry cells to the battery side (B) of coil, per fig. 8, and turn switch to B, or right side.

If the engine then starts, and runs satisfactorily, but will not start on the magneto, with switch to the left, or M side, then you may know that the magneto is not supplying current. It may be due to dirty or loose magneto terminals T, (see fig. 7 below and page 805), or a weak magneto, due to weak magnets, or grounded magneto coils.

The Ford magneto can be tested with a special magneto tester, called the "St. Louis," see figs. 6 and 7. This instrument is nothing more than an ammeter, but one provided with a "reactance coil" (R) fig. 7, which enables the meter to indicate a constant current at all engine speeds. In other words, the meter is so designed, it will indicate if magneto is giving its proper output at any speed of engine while testing.

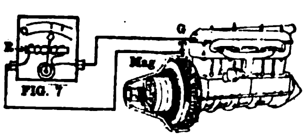


FIG. 7

This instrument can be used to test the strength of the magneto while engine is being run on a battery—if engine fails to start on magneto. If engine starts on magneto, but continually misses and is not due to other causes, then the tester can be used to see if magneto is delivering its proper current—while engine is being operated on the magneto. The connection for testing would be the same in both cases, per fig. 7, except, when running on battery, the wire from ignition coil to magneto is removed and switch placed on B side fig. 8.

The tester is a great help when assembling magneto on the bench, The "air-gap" can be adjusted to the point of greatest output, if you have the meter to test with as you assemble. The fly wheel can be turned by hand fast enough, so that instrument will give a steady reading.

"Air-gap," is distance the magnets are from core of magneto coils (see fig. 91, pages 805, 806.) This should be $\frac{1}{32}$". If further away the amperage and voltage will be less; if closer, it will be greater, but there is a liability of the magnet striking the coil core.

To test air gap space and strength of magneto on car: (1) Test output of magneto with Tester, fig. 6, with engine running moderate speed; (2) Remove transmission cover and place a thickness gage, $\frac{1}{32}$", between magnet and coil core. If gap is $\frac{1}{32}$", but magneto has tested out as **weak,** magnets need recharging; (3) After remagnetizing the magnets (which can be done without taking engine down, see below), then test magneto again with engine running moderate speed. The tester should show **strong,** if not, then the probabilities are the magneto coil is short circuited.

If some of the magneto coils become short-circuited, or if magnets are weak, the tester will read low. In other words it tells you instantly, without removing the magneto from engine, if the magneto is in proper condition. If not in proper condition then it is time to take magneto out and remedy the trouble. If it tests o. k. then it is time to look elsewhere for the trouble and you will thereby save the time of having to remove the magneto in error.

The meter scale is very simple, it has two readings, see fig. 6. One marked "1914," meaning that all magnetos **before** 1915, the needle should come to this mark. The other is marked "1915," meaning that all cars **after 1915,** the needle should reach this mark. (The Ford magnets were enlarged in 1915).

If the needle fails to reach this mark, then remagnetize the magnets without removing from engine, as explained on page 819 and below. If then, the magneto fails to test up to this mark and the missing still occurs and is not due to loose terminals, and runs satisfactorily with a battery, then you may know you have a "grounded" magneto coil, and magneto must be removed, defective coil located, another put in place and then "air-gap" clearance given as per above.

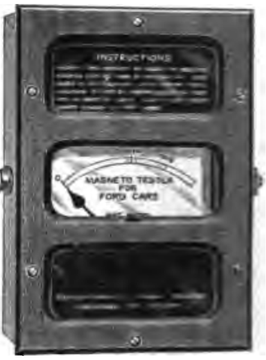


Fig. 6. Ford Magneto Tester. Note how the scale is marked. See text.

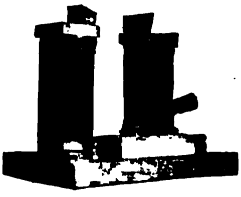
This device is one of the most useful accessories a Ford repairman c

Price with full instruction

IGNITION COIL TESTER AND MAGNET REMAGNETIZ

Ford Ignition Coil Tester: Consists of base, switch and ammeter. Coil should show a reading of about 1½ amperes and a continuous spark across ¼ in. gap. Full instructions. **Price** complete ...$6.00

This outfit will assist you in testing and adjusting ignition coils accurately.



Mag

izer.

consists

f u l

mount

base

two binding

Operated fro

volt or

age

cell

all

Price complete with full instructions....

Extra for attachment to charge Ford mag

without removing from car (see pa

Address **all** orders to A. L. Dyke Elec. Dept., Granite Bldg., St. Louis, Mo.

MOTOR-GENERATOR SETS—For Charging Storage Batteries.

Only "direct" current can be used to charge storage batteries, but in most towns and cities only alternating current is available.

There are three methods of charging batteries where only alternating current is available:

1: By the use of a **Rectifier,** as explained on pages 462, 463 and as advertisement, page 864-L.

2: By the use of an electric motor which will operate from alternating current and then have this motor drive a dynamo or generator which will generate "direct" current, from which current the battery is charged. This motor and generator is then "direct connected" on the same base and is called a **Motor-Generator Set.**

3: Instead of an electric motor being used to drive the generator, this direct current **generator can be driven by belt power from a line shaft** or gasoline engine or other power—per page 462.

Where a limited amount of battery charging is to be done, the Rectifier per page 864-L is recommended.

Where many batteries are to be charged, the Type 9G "St. Louis" Motor-Generator Set, shown below, is recommended.

St. Louis Type 9G Motor-Generator Set

is shown in fig. 1, and consists of the following parts:

1—1¾ h. p. **motor** to be operated from alternating current. This motor can be supplied to operate from any voltage or phase and this information should be obtained from your local electric plant when writing to us.

1—**Generator** or dynamo, which is connected to the above motor and generates "direct" current. The generator is of 1KW (one kilowatt) capacity, or 83 volts at 30 amperes.

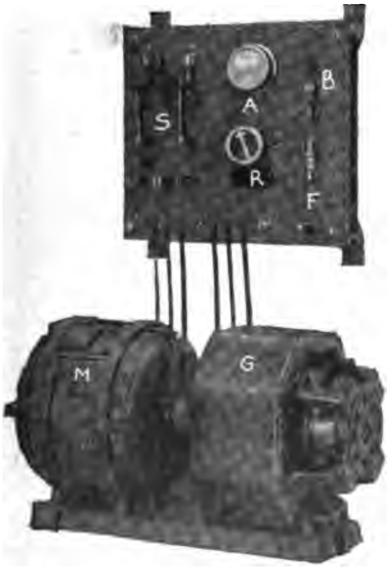


Fig. 1—Type 9G, St. Louis Motor Generator Set.

1—**Switch-board,** also called "charging panel;" parts of which are: a slate base, on which is mounted motor switch (S), which is connected with the alternating current source and the motor. Ammeter (A) is connected between generator and battery being charged and indicates ntity of current flowing to battery when ging. Field rheostat (R), connects with winding of generator and regulates the ntity of current which can be made to flow ttery, or batteries being charged.

Fuses (F) are provided to protect generator and battery circuit and motor. B is the switch to generator and battery.

The type 9G motor-generator set will charge from 1 to 5 batteries in series at any amperage rate up to 30 amperes, by throwing in or out the resistance of field rheostat (R). Fig. 2, shows the connections when charging 5 batteries or less number.

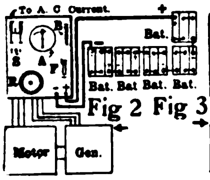


Fig 2

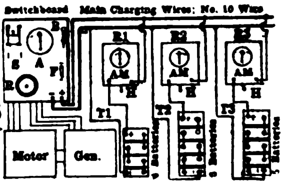


Fig 3

As many as 20 batteries can be charged at one time, with this Type 9G, by adding Auxiliary Rheostats.

For instance, suppose it is desired to charge 14 batteries. It will necessitate three different charging lines and the use of three auxiliary Rheostats, as R1, R2, R3, fig. 3.

Suppose you desired to charge 4 of the batteries at 10 ampere rate and 5, at 6 amperes and 5, at 4 amperes. You will readily see that the current which would be drawn from generator would be 20 amperes, as adding 10, 6 and 4 we have 20 amperes. Therefore, we will connect an auxiliary rheostat R1, as shown. In this way we establish an independent charging line. Then to terminals T1 of this line, the 4 batteries to be charged at 10 amperes are connected in series. Then connect 5 batteries in series to auxiliary rheostat line R2, at terminals T2. Then the other 5 batteries connect to R3 terminals T3.

Place each rheostat hande (H) of R1, R2 and R3, so that all resistance is "cut-out." Then set the charging rate of generator, by moving shunt field rheostat on switch-board until ammeter (A), on switch-board, shows 20 amperes. Then note the reading on each of the ammeters (AM), on the auxiliary rheostats. A little resistance can then be cut in or added to the line that is taking most of the current until each of the 3 lines is cut down to the proper amount of current at which it is desired to charge each lot of batteries.

Price of Complete Motor-Generator Set, Type 9G, including switch-board, motor and generator $224.00

The Auxiliary Rheostat

Auxiliary rheostat

fig. 4 and 3, are supplied separate, including slate base, ammeter in front and resistance coils in rear, which are made of resistance wire, wound on asbestos board and placed about ¾-inch apart, lengthwise on back of slate. The resistance is cut in or out with handle (H). The ammeter on rheostat indicates charging rate on that particular rheostat line, whereas the ammeter on switch-board indicates total amperes to all lines, or to 1 or 5 batteries if charged without this auxiliary rheostat. The maximum carrying capacity of auxiliary rheostat is 10 amperes.

Price, each $7.00

—continued on next pa

*Type 9G Direct Current Generator

Can be purchased without the Motor but with a pulley, from which it can be operated from a line shaft by belt power, per page 462, or by a gasoline engine or otherwise.

Price of 9G Generator complete with switch-board and pulley $122.00

The 9R Switchboard For Direct Current

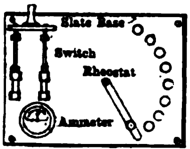


Fig. 5. Switchboard Type 9R

Can be purchased separate where you have your own direct current dynamo (generator). This switch-board (fig. 5) is arranged slightly different from 9G and is known as the 9R switchboard. It consists of a square slate panel 15½"x13", mounted on cast iron brackets to fasten to wall. On back of panel, the resistance is mounted with 9 taps (see page 464, fig. 11; for meaning and purpose of "taps"), which are controlled by handle in front. An ammeter to show charging and the controlling lever makes contact with resistance taps, regulating the charging current so that from 1 to 9 batteries may be charged at one time in series. The normal charging current is 6 amperes. The switch, with fuses for connection to dynamo is mounted in front.

Price, complete $20.00

RECTIFIERS—For Charging Storage Batteries.

"St. Louis" Rectifiers.

Battery charging and repairing is a profitable business. In most towns however, the electric current is "alternating," whereas only "direct" current will charge a battery. Therefore some means must be employed to convert the alternating current to direct current, as explained on pages 463 and 864-K. Where only a limited amount of charging is done the rectifier is advisable.

The St. Louis Rectifier consists of a transformer and a vibrating unit and ammeter, as explained on page 465, fig. 62, and per illustration below.

The transformer can be wound with as many secondary windings as there are vibrator units. For instance, a transformer with one secondary winding and one vibrator unit will charge 1, three-cell battery and would be termed **Type 1M.**

In the illustration below, there are five vibrater units and five windings on the transformer, therefore it will charge 5 batteries and is known as **Type 5M.**

A larger type, 10M rectifier consists of a transformer with 10 secondary windings for connection to 10 vibrator units. Each unit will charge a three-cell battery at a 6-ampere rate. Ten three-cell, 6-volt batteries may be charged at one time at a 6-ampere rate. Twenty three-cell, 6-volt batteries may be charged at one time at a 3-ampere rate.

Batteries of any voltage used on automobiles for starting, lighting and ignition can be charged with this type. Each battery is charged on an individual circuit, which is an excellent feature as the correct temperature can be maintained. Length 5½ ft., shipping weight 152 lbs.

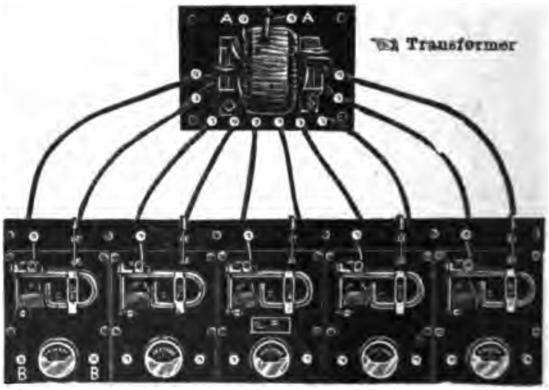
Each vibrator unit is suppied with an ammeter, so that the charging rate can always be noted at a glance.

Prices For

Type 10M, with ten vibrator units, suitable for large shops, each with ammeter.......	$140.00
Type 5M, will charge 5 three-cell batteries at 6-ampere rate	80.00
Type 1M, for charging 1, 6-volt battery at 6-ampere rate with one unit and ammeter..	20.00
Type 2MB, for charging a 12-volt battery at 6-ampere rate or two 6-volt batteries at 6 amperes each	40.00
Type 3MF, for charging 6, 12, 18 and 24-volt batteries at normal charging rate of 6 amperes to each unit, but will charge at 12 amperes if desired. Has 3 vibrating units	60.00

Transformers: If you desire, you can purchase the type 10M Transformer with 10 windings for $40, or the 5M Transformer with 5 windings for $30. **You can then purchase a single vibrating-unit for either type,** for $11 each. Then as your business increases, you can purchase other vibrating units until the complete number are obtained —for either the 10M or 5M transformer.

Note—Above prices for 110 volt, 60 cycle current. Other cycles cost more. Ask your local electrical plant for the cycle, before ordering.



Type 5M Rectifier with Transformer with 5 secon windings for connecting to 5 vibrating units (below transformer). The outside AC current wires co to transformer at A, and battery connects tor units at B.

WE REPAIR MAGNETOS—Also Coils, Generators, Starting M

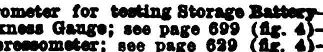
Send defective Magnetos, Generators, Starting Motors, Coils, etc. to us prepaid, **test out and advise you the cost of repair** before proceeding with the work.

"Lessons in Practical Electricity."

A book thoroughly simplified, treating on the first principles of electricity.

517 pages; 404 illustrations; 102 experiments; 154 worked out problems; 438 review questions.

Price. $2.00



Hydrometer for testing Storage Battery—
Thickness Gauge; see page 699 (fig. 4)—price
Compressometer; see page 629 (fig. 4)—price
Townsend Grease Gun; see page 622—price

all orders to A. L. Dyke, Elect. Dept., Granite Bldg., St. Louis, Mo. *Speed of generator, 170

DIXON'S
GRAPHITE GREASE
No. 677
FOR
TRANSMISSIONS and DIFFERENTIALS
JOSEPH DIXON CRUCIBLE COMPANY

Run Up Mileage

More miles per gallon for your "gas"—more miles of steady running per season if you use

DIXON'S GRAPHITE Automobile LUBRICANTS

The squeak is the cry of the wear and tear of friction, caused by the grinding of miscroscopic spurs, pock-pits and other roughnesses that are present in even the most highly polished bearings. Oil and grease stop the squeak, but do not eliminate the grinding.

Dixon's Selected Flake Graphite fills up these irregularities of surface and makes a smooth, oily veneer that grows harder and smoother the more it is rubbed and used. To lubricate without balling up, the graphite flakes must be peculiarly thin, flexible, oily and absolutely free from impurities. on's is absolutely the only graphite that has these qualities.

There's a special Dixon Graphite Lubricant for every part of your car. by all dealers and garages where you can rely on the best of everything.

Write for Booklet No. 116-G, give us the name of your car and we will free the Dixon Lubricating Chart.

Made in Jersey City, N. J. by the

oseph Dixon Crucible Company

ESTABLISHED 1827.

What Does Your Oil Do?

Does It Lubricate Correctly—Save Power—Protect Your Motor? Or Does It Just Burn Up?

IF YOU have checked up the mileage which different oils yield, you have probably found that some oils are consumed more rapidly than others.

If an oil too heavy in *body* is used, it will fail to reach all friction points.

Often an oil is too light in *body* for the motor's mechanical conditions. Excess oil then gets by the piston rings. Reaching the combustion chamber it burns.

When oil consumes rapidly power-waste also occurs. The fuel charge escapes past the piston rings on the compression stroke. Gasoline consumption mounts up.

Even with oils of correct *body* a minute quantity of the oil works past the piston rings and is burned up.

But with oils of *incorrect body* this consumption becomes rapid. It results naturally in sheer oil waste—and in excess carbon deposit.

To first-time users the "wear" of Gargoyle Mobiloils is often astonishing. This is due in part to their unusual ability to "stand up" under the heat of service—and because they maintain a proper seal between pistons, piston rings and cylinder walls—*i. e.*, have correct *body*.

In short, the oils stay where they belong. They are not burned up by working in excess quantities into the combustion chambers.

The Vacuum Oil Company's complete Chart of Recommendations will be mailed to you upon request.

GARGOYLE

Mobiloils

A grade for each type of motor

Gargoyle Mobiloils provide correct lubrication. They combine the highest lubricating efficiency with the correct body and character necessary to suit the lubricating requirements of every make and model of automobile when used as specified by the Vacuum Oil Company's Chart of Recommendations.

We recommend Gargoyle Mobiloils highly.

VACUUM OIL COMPAN

New York, U. S. A.

Specialists in the manufacture of high-grade lubrica every class of machinery. Obtainable everywhere in the wor

Domestic Branches
New York
Boston
Philadelphia
Pittsburgh
Chicago
Detroit
Minneapolis
Indianapolis
Kansa
Des Mo

GENERAL INDEX.

If you don't find what you want under one heading, stop and think—what other heading it could be under. For instance, if you are looking for the adjustment of floats of carburetors, it may be under; "carburetor float adjustment," or "adjustment of carburetor float," or "floats for carburetors."

Another point—If you want to find how to adjust the carburetor on some particular car. First turn to Specifications of Leading Cars, pages 543 to 546; find the make of carburetor used, then turn to the index for that particular carburetor and the pages whereon it is described. The same applies to **ignition and electric systems.**

See Dictionary page 861, for Meaning of Motoring Terms. See page 767 for Ford index.

A

Acceleration; meaning of 150
Accelerator 496-497-154-486-67-153-492-150-497
Accessories, desirable and necessary..........511-515
" for car 17
" for tires 568
Acetylene regulator 720
" for welding 718
Acid; meaning of 489
" for battery; how mixed 448
" (picric) for increasing speed and power....809
" -proofing battery boxes 473-474
" test of platinum points..............304-284
Active material, of storage battery..............439
Address of Auto publications.........520-524-529-753
Addresses, how to find....................548
Address of mnfg'r's of air compressors..........610
" " " " automobiles 588
" " " " bodies 762
" " " " carburetors 162
" " " " electric systems 873
" " " " engines..........Insert No. 2
" " " " gasoline tanks 602
" " " " ignition systems...251-253-254
" " " " magnetos 288
" " " " parts of old cars..........547
" " " " pistons (aluminum)....651-823
" " " " pistons, rings, etc.....609-823
" " " " machinery for repair shop.617
" " " " starters (mechanical & air).822
" " " " steering gears 691
" " " " storage batteries 473
" " " " tire accessories 568-571
" " " " tires 571
" " " " top material 849
" " " " touring equipment 520
" " " " tractors 753
" " " " wire wheels 762
Adjustable engine bearings 643-837
Adjusters for valves 608-634-791
Adjusting and inspecting engine parts............595
" " repairing 620
" Atwater-Kent ignition device.......248-250
" auxiliary spring on carburetor.........168
" Bendix starting device..............326-331
" Borg and Beck clutch...........42-668-842
" Bosch ignition timer 253
" brake pedal 691
" brakes, Timken and others......684 to 689
" Buick clutch and transmission......665-670
" Cadillac carburetor 180
" carburetor and engine tuning, prices charged....................595
" carburetors, different makes.166-171-172-184
" carburetors, "V" type engines.........171
" carburetor for winter 170-153
" chain tension 749
" Chevrolet clutch and brakes........665-672
" Chevrolet transmission 671
" clutches . ...661 to 668-932-842
" coil vibrators 234
" Connecticut ignition timer..............254
" connecting rod bearings.641-643-645-646-837
" cut-out 898
" Delco electric system 897
" Delco third brush 390-405
o timer 245-378-392
rential driver pinion.......673-674-677
ge clutch; transmission..666-670-981-932
ge generator 733
ne 595-620
ne bearings 641-643-837
....................191
s of carburetors 182
t wheels 680-681
floating axle..........669-673-677-932
of magneto interrupter.....297-304-301
ity of battery 471
llights 433-432
son clutch 666
son oiling system 694
tion timer 245
rnal gear drive axle....................678
rrupters 264-298-244-251-253-304
ton horn 514-418
Adjusting magneto interrupter 297-298-304
" main bearings of engine..............887
" Maxwell transmission 670
" McFarlan rear axle 673
" Mitchell transmission 671
" oil pressure 198-199-200-694-859
" Overland clutch 666
" Overland transmission 670
" piston clearance 645-649-651
" rear axle and differential...673-674-678-932
" Reo clutch 667
" Reo engine bearing 643
" "safety or spark gap" magneto........291
" screw (carburetor) 148
" Sheldon rear axle (truck type)....750-751
" silent chains 411-728-729-369
" silent chain (Dodge)..................369
" spark plug gap............233-235-542-237-238-304-939-275
" semi-floating axle 669-674
" Schebler carburetor 172-174
" steering devices ....690 to 693
" Stewart horn 515
" Studebaker clutch 665
" Studebaker transmission 670
" third brush on generator 370-733-924-925-405
" three-quarter floating axle 669-672-675
" timer 247-254
" transmission 669-671
" truck brakes 751
" universal joints 680-681
" vacuum tank fuel feed....................165
" valve and tappet clearance......94-684-685
" valve clearance, Buick 109
" valve tappets (wrench for)............788
" vibrators on coils 234
Adjustment of axles............669-672 to 679-750-932
" " rear axle, Buick..............676-677
" " " " Cadillac 674
" " " " Chalmers 674-678
" " " " Dodge 932
" " " " Dorris 673
" " " " HAL 673
" " " " Hudson 674
" " " " Jordan 674
" " " " Maxwell 675-676
" " " " Reo 679
" " " " Sheldon truck 750-751
" " " " Saxon 678
" " " " Westcott 674
Advantage of a circuit breaker....................877
" " balanced crank shafts 582
" " chain drive 19
" " dynamo for ignition 255
" " single hot spark 225
" " three point suspension 533
" and disadvantages of auxiliary air valve (carburetor) ...150
" " " " battery coil and magneto 255
" " " " coil with vibrator 255-230
" " " " coil system of ignition 255
" " " " dry batteries......255
Advantages and disadvantages of generator for ignition 255
" " " " ignition systems..255
" " " " low tension coil systems 255
" " " " magneto system alone 255
" " " " master vibrator coil 255
" " " " mechanical features of cars....531
" " " " oiling systems....197
" " " " solid tires 527
" " " " storage battery for ignition.....255
Advance and retard of interrupter..............809
" " " " spark 67-227-305-314
" " " " spark, how much 227
" " " " spark, magneto 267-294-277-309
" of ignition, testing of..................817

See page 898 for English to French Dictionary.

Advance of spark, automatic 246-249
" " spark, range of 312-319
Airplane engines (see supplement)....901-757-133-933
" engine spark plug 238-939
" instruments 920-921-904
Age of person driving a car..............522
Air and gasoline, (mixture)..............142-150-151
" and gasoline, proportion of..............586-142
Air bled jet 177-800
" bound gasoline tank, caused by..............162
" compressors 562-563-564-553
" compresser (homemade) 748
" compressor, speed of 568
" control for carburetor 159-170
" cooling 189-190
" gap 95-480-864J
" gap of valve 94-95
" gap transmission 480
" gauge (Twitchell) 568
" hose 568
" leaks 192
" lock in water line 192
" planes (see supplement)..............901
" pressure, gasoline system..............164-602-180-854
" pressure of tires..............558-554-559
" pump 562
" starter 322
" tank for cleaner 740-744
" tank, pressure alarm..............740
" tank, size to use 564
" type speedometer 512-518
" valve control of carburetor 149-178-166
" valves (weighted), of carburetor..............150
" washer for carburetion 828-754
A. L. A. M. horse-power table 584
" " meaning of 584
" " size spark plug 238-612
Alarms 515
Alcohol and water (non-freezing)..............198
" for cleaning spark plug..............237
" freezing, boiling point and specific gravity..585
" kerosene, water, gasoline, freezing and boiling point 198-585
" how to save 780
Aligner for wheels 688-744-787
Alignment of pistons and connecting rods..646-649-659
Alignment of truck transmission..............749
Alignment of truck wheels 565-588-688-750
Aligning transmission shaft 782
Allen spark and throttle control 496
Alternate peak of current wave..............265
Alternating current 257-266-267-385-489
Alternating current generators 257
Aluminum cleaning of 401
" melting point 721-589
" pistons 75-645-792-818-651
" piston kinks 651-688
" soldering 695
American Ever-Ready speedometer..............513
Ammeter 415-414-377-398-399-402-410-416-864H
" does not indicate charge..............415-416-410
" exposes short circuits..............417-416
" for testing adj. of coil vibrators..............284
" how placed in circuit..............410-391
" indications 410-416-417
" on Reo-Remy electric system..............372
" principle of 414-398-415
" purpose of 410-414-415-377
" reads charge at low speeds, discharge at high speeds, etc..............411-410-416
" readings 414-399-400-417-419
" " during cranking operations, Delco.387
" scale 414-398-399
" shunts 414
" testing accuracy of 410-398
" testing for short circuits..............406-418
" tests for motor, generator troubles...416-410
" to test battery indicator and cut-out.....410
" troubles 419
" vibrates 400
" when used with starting motor..410-414-416
Ampere and volt, meaning of..............207-441-439
" as applied to generators..............337-410
Ampere capacity of wire..............427
Amperes, consumed by electric lamps..............433-434
" consumed by starting motor..............410-416
" consumed by electric vehicle..............477
Ampere hour 439-441-861
" hour capacity of battery..............861-441-467
" -meter—see also ammeter....403-402-414-410
Amperes, how to measure 414-410
Amperage of Delco generator 390
" " generator, average 371-410
" " lamps 432-433-467-410
" regulation 343
" to speed of generator..............390-410
Anderson valve grinder 616
Angle iron 710
Annealing 718
Annular ball bearings 36-565
Anti-clockwise and clockwise 296-313
Anti-freezing solutions 198-438
Application of starting motor to engine..............337
Arbor press 605
Arc burning, meaning of 439
Arc burning outfit for battery..............471
Area of a circle 580
Area of a triangle 589
Army truck gear shift..............490
Armature 257-335-274-323-325-337
" coil, if burned out 411
" construction of, for magneto.269-271-290-304
" core, laminated 258
" displacement type 330
" high tension 271-268-283-290-304
" how one serves for motor and generator 347-352-381-387
" inductor type 264
" inductor type magneto 256-265
" (magneto) speed of inductor type 265
" of generator 212
" " magneto and interrupter, position of..309
" " magneto, setting of 295-310-313
" " magneto, speed relation of....296-306-313
" relation to interrupter 309
" relation to distributor on magneto..............301
" shaft 275
" (shuttle type) 256-258
" speed, of magneto 294-424
" torque test 411
" troubles 411-416-301-304
" winding, magneto..............256-258-268-269-271
" winding (Delco) 381-387
" tests 402-406-410-414-416-424-418
" test (magneto) ....301 to 304
" winding, generator 323-325-332-335
Artillery type wheels 15
Asbestos gaskets 717
A. S. M. E. screw thread table 703
Assembling a four cylinder engine 62-63
" truck rear axle 751
A. T. M. (atmospheres), meaning of..............433
Atmospheres, reading of 436-433
Atmospheric pressure 718-582-168-920
" " at sea level 589-920
Attaching and detaching tires..............555 to 558
" charging wires to battery..............780
" magneto to engine 301
Attachments for carburetor 158
Atwater-Kent, a single spark 250
" " depolarizer switch 248
" " ignition system 247
" " ignition system, adjusting of...248-250
" " system, wiring of 249
" " timing for Ford..............810-818
" " timer gap 250
" " timing, oiling of 247
Automatically operated inlet valve 91
" " needle valve 172
Automatic advance governer 248-249
" " of magneto 287-289
" " of spark 246-249
" " reason for 307
" controller of electric current..............342
" control of spark, Delco..............376-388
" cut-out 337-334-342
" electro magnetic gear shift..............330
" gas generator 437
" regulator, electric ....343 to 350
" shifting pinion starter 326-331-330
" spark control 246-249
Autogenous welding 719
Auto Club of America 582
Auto-lite cut-out 359
" " starter and generator, on Chevrolet.364-358-359
" " generator brush adjustment..............364-358
" " generator fails to generate full output 409-358
Auto mechanician, meaning of 594
" mechanicians outfit 592-594
Auto-Ped 755
Auto race, first 581
" right side of 582
" salesman and pointers ....529 to 538
Auto show, first 581
" trade publications 589
" words, pronunciation of 583
Automobile; assembly of 19
" cleaning of 507-535
" electric 478
" first 581
" functions of principal parts.............. 19
" how to ship 549
" laws, different states..............522-538
" manufacturers' addresses 533
" overhauling of 594
" repairing business, how to start..............597
" repairman 593
" right side of 134

Automobiles no longer manufactured, where to obtain parts 547
Auxiliary air inlet 147
" air valve, its purpose....150
" air valve (Packard) 855
" hand air pump for gasoline....854
" head lights 857
" spring adjustment on carburetors....168
Average valve timing 114
Aviation engine, Gnome (see supplement)....138
" engine, Wisconsin—see supplement.
Axle **adjustments** ....669-672 to 679-750
" **shafts** (Cadillac) removal of....679
" **shafts**, how fastened to differential....669
" **stand**, for repairing....605-730-797-709
Axles . ....2-31-50-669-672 to 679-750-931
Axles (dead) 31-746
" **floating** and semi-floating, advantages of 532-669-31
" **front** 31
" **full** floating 31-33-669-532-931
" **housing**, lubrication of 204-205-669
" **internal** gear drive 678
" **live** 31-50
" **oil** leaks 678
" **rear** 31-33-532
" removal of 33-932
" **semi-floating** 33-669
" straightening of....709-737-782-584

B

Back-firing in muffler 580
" " (popping in carburetor)....170
" " valves open too early.... 98
Back lash, taking up 673
Bacon, how to cut 518
Baffle plate to prevent excess of oil....652
Baker bolted-on rim 557
Balanced crank shafts 532-122-78
Ball **air** **adjustment** of carburetor....150
" air inlet of carburetor 152
" and Ball carburetor 864F
" **and** **socket** **gear** **shifts** 490-49
" **and** spring oil regulation....198-200-741
" **bearings** 36
" **bearings** for engine 640
Ballast coil 339
" resistor 347-348-428
Barrel type crank case, explanation of.... 62
Barnes steering device 691
Bases **for** electric lamps 483
Batteries, (dry) weak 241
" how rated in ampere hours....416
" sulphated 456-448
" two sets how used with coil....226
Battery (storage) see also storage battery..439-421-411
" " action of 447
" " acid 448
" " adding water 454-455
" " adjusting gravity 471
" " and coil ignition systems...242-245
" " " dynamo lighting method...431
" " assembly 444
" " electricity not stored....447
" **box**, acid proofing or painting....473
" **capacity** 441
" **care** of 454-421
" **case** 469
" **cell** **assembly** 445
" **cell** **connections** 443
" **cells** 445
" charge, when complete 459
" (12 volts) charged from a 6-volt generator.863
" **charging** 459-447-470
" " and repair shop 601
" " (12 volt) battery from 6-volt circuit 465
" " circuit 461
" " equipment (lamps) 460-461-465
" " Ohms resistance 464-463
" " outfits 462-464
" " pole finding not necessary with rectifier 463
Battery charging principle, simplified 447
" " rate 459-461-467
" " rectifiers 463
" " resistance required 461
" " reversed 459
" " volt meter test....460-453-461-416-410-864D
" " when sulphated 461
" cleanliness 455
" cold weather 422
" coil and magneto, disadvantage of....255
" coil timer and magneto ignition....276
" compound for sealing 474
" connections, (miscellaneous)..422-428-444-466
" connector, boring of—to remove....468
" connectors, burned and bolted 468
" connectors, burning of 470-471-472
" connecting to generator....421
Battery constantly discharged 422-416-410
" construction 443
" cracked, sealing compound 473-474
" current, direction of flow....444
" current, how to save 422
" disassembling 463
" discharges 422
" disconnecting of 423
" disconnecting on Reo 372-423
" discharge and overcharge 448
" does not stay charged 422
" double voltage system 456
" (dry cell) 207-210-214
" (Edison) 475
" electrolyte 448
" " freezing point of 451
" " spilled 455-473
" " put in same cell....451
" element, what constitutes....442-445
" element assembly 470
" filling cell with electrolyte after repairing..470
" floating on the line 334-337
" (forming the plates) 447
" for starting and lighting 421
" gassing 447-439
" gives out on road 584
" gravity at end of charge....461
" " constantly high 458
" " low, cause of 457
" " meaning of 447
" (gravity of) for starting motors....451
" gravity too low 458
" grid 445
" grounded 425
" heating of 448
" how to crate for shipment 473
" how to determine size to use....443
" how to determine the number of cells, plates, etc. by number on battery....443
" how to disconnect 423
" " " remove bad plate 469
" " " seal 470
" " " tell when charged 450
" " " tell when needs charging....458
" hydrometer for testing....450-447-451-457
" hydrometer reading, when to take....451
" idle for long period 455
" if charged and new solution added....470
" if repaired for a short circuit 470
" impurities in electrolyte 469
" indicator 410
" information, (miscellaneous) 470-471
" inspection of parts 469
" internally short circuited 418-422
" jar 444
" jar cracked and trouble....471-457-586
" (lead burned) joints 445
" lead sulphate forming in 447
" manufacturers address 473
" negative gives less trouble than positive..469
" of electric vehicles 477
" (on Buick) 442
" overcharge 448
" overheating 457-458
" out of service 455
" parts of 442-444
" paste for plates 445-447
" plates buckling 456-457
" plates, color of 445
" plates (Plante and others)..445-440 to 442-444
" plates, straightening of 468
" plates, sulphated—cause of....456-457-448
" plates, why odd number....446
" pointers 458-459-416
" poles, how to determine 212
" put in use after long period 455
" reassembling of 470
" rectifier, home made 463-464-466
" removing of 423-845
" repairing . ....:463-471-472-456
" repairmans tools 474-414
" resistance units 463-464
" reversed connection 421-459
" sediment, causes of....457-469-456
" separators, (inserting) 468-470
" short circuits, usual causes of 456
" solution 448
" specific gravity 449-451
" sulphation 448-456-457
" supplies 474-473
" (6 volt) supplying 3 volt lamps....466
" (18 volt), supplying 8 volt lamps....466
" (24 volt), supplying 12 volt lamps....466
" temperature 449-461-471-448
" terminal properly grounded....408
" terminals 439-421-458-471
" terminals how to connect....421-445
" terminals reversed 421-417
" terms, meaning of 439
" tester 452-450-416-410
" test for short circuits....413-406-416

Battery testing with switch off 421
'' test with volt-meter 416-410-453-864D
'' thermometer 449-450-451
'' troubles, cold weather 422
'' troubles, miscellaneous 416-421-422-456-457-458
'' troubles, remedies for 416-422
'' troubles located with hydrometer 457
'' type numbers explained 443
'' voltage 443-453-370-440-447-410-416
'' voltage at end of charge..461-453-460-410-416
'' volt-meter for testing........414-410-416-453
'' water, adding proper kind 454-455-456
'' water, how to distill.................474-709
'' weak 421-422
'' when cut-out is not used with...........422
'' when disconnecting 421-423
'' when to put in separators 470
'' when to tear down for repairing 463
'' will not take charge............458-416-410
'' wood and rubber separators.......445-444-469
'' work bench 474
'' work, prices to charge 473
Baume scale 452
Bayonet lamp base 432
Beads of tires, types of 552-553
Bearing bushings 641-648-644
'' (engine) adjustments 641
'' knocks, how to test for.....................638
Bearings, plain 72-644-208-641-837
'' (adjustable type) 643
'' burnt and ''burning in''..............643-201
'' connecting rod 72-647
'' engine, how oiled 198-200
'' engine, testing 507-641-643-507-837
'' engine worn, how to determine..........647
'' fitting to engine 647-837
'' for engine and adjusting of 72-640-507-837-838
'' for piston pin 644-643
'' now damaged 202-203
'' kind used on leading cars..................543
'' main and connecting rod, fitting....641-647
'' Packard ''twin-six'' 853
'' (oil grooves in) 208-644
'' roller, ball and thrust..36-673-674-687-640-588
'' scraping of 642-643
'' six cylinder engine 123
'' taking up and testing 641-837
'' Timken roller 687-673-674-36
'' worn 641
Beams of light, meaning of 433
Bell crank; on brake rods 6
Belts for fans 187
Bench drill 613
Bending tubing 713
Bendix electric starter 326-331
'' starting motor drive method..........331-342
'' starter system, care of 331
Bent fenders etc.; how to straighten..........745-731
'' frames, how to straighten.....................731
'' axle, rear and front.........709-737-782-584
Benzol 589
Berline; definition of 15
Berling magneto 304-312-926-927
Bevel gears 35-19-780
'' '' how adjusted 21-673-674
'' '' spiral type 21
'' '' where principally used 21
'' '' worm type 21
'' type steering device 692
Bezel, on what used 512
Bicycle; high and low gear 12
Bijur double gear drive motor..................328-857
'' generator and controller...............857-925
Bins for the stock room 606
Bi-polar 828
Biplane 900
Blacksmithing, equipment for 615
Black smoke, cause 202-652-169
Block and tackle for pulling car out of hole......734
Blow cock for air line 739
Blow-outs and why 566-590
Blow-out of inner tube 572
Blow-out of tire 566
Blow-outs, repairing of, with electric vulcanizer..575
Blown fuse 428-415-417-419-420
Blow pipe torch 592-711-718-615
'' torch, home made 696
Blue book for touring 520
Blue smoke, cause 202-652-169
Boat horns 514
'' Ford engine in 825
Bodies; classified 15
'' metal; how to straighten 745-731
Body builders, addresses of 762
'' polish 507-508
'' removing of 678-743
'' what type to use 527
Boiler of steam cars 763-764
Boiling point of water, alcohol, kerosene, gasoline..585
Bolts and screws, S. A. E. and U. S. S.........612-701
Book (guide) for touring 520
's on lathes 617
Books on oxy-acetylene welding.....................719
Bore and stroke, meaning of 31
'' '' '' of engines of leading cars..542 to 546
Borg and Beck clutch 42-668-842
'' '' '' '' adjustments 668
Bosch, battery and timer ignition.................276
'' double ignition system 276
'' dual magneto, timing of 312
'' dual magneto relation of armature to distributor 301
'' ''DU4'' magneto and synchronizing of.301-268
'' electric system on Marmon 361
'' generator principle 339
'' ignition timer and adjusting of 252-253
'' interrupter (magneto) 298
'' magneto 288
'' ''NU4'' magneto system 284
'' starting motor 330
'' ''two point'' ignition system 277-284
'' ''two spark'' ignition system........277-288
'' vibrating duplex system 283
'' ''ZR'' magneto, setting of 310
Bottoming tap 704
Bowden wire 301-173
Box pit, for working under a car 739
Boyce motometer 188
Brake adjustments ....684 to 689
'' '' Chevrolet 672
'' cam type 686
'' care of 685
'' cleaning of 688-690
'' (clutch) 665
'' bands, fitting 688-689-690
'' bands, how to clean 568
'' drums; where located...............6-684 to 689
'' electric 479
'' external contracting band type...........686
'' equalizer 30
'' fails going down hill 583
'' horsepower 585
'' how to use 494-491-492
'' horse-power test 586
'' if fails 495-491-492-583
'' internal contracting band type.............686
'' lining 688-691-689-690
'' lining counter sink 616-690
'' overhauling of 688-689
'' pedal adjustment 691
'' Presto vacuum 479
'' purpose of 11
'' squeaks 30-684
'' Timken type 684-686-687
'' toggle type 687
'' truck type 751
'' types of 29-686-687
'' using engine for 494-583
Brass and nickel polish 508
'' cleaning of 401-741-508
Brazing 697-712
'' torch 712
Bread, how to bake 519
Breaker box, how to install 254
'' gap distance of magneto..............288-298
'' points, magneto 312-298-309
Breast drill 614
Breather, purpose of 197-783
Briggs standard thread 703
Briscoe spark and throttle 497
'' specifications 543
'' wiring diagram 363
British Columbia auto laws 524
Broken gasoline pipe..................................712
'' piston rings 591
'' wires, testing of 241
Bronze bushings 644
Brougham; definition of 15
Brush type distributor 269
Brushes, broken connection indication.............412
'' carbon and metal (Delco) 404
'' care of 406-408
'' electric motor 325-331
Brushes holder loose 408
'' how to change charging rate by shifting (Delco) 405
'' sparking at 409
'' fitting of 406-404
Bryant valve spring remover 616
B. S. gauge of wire 427
Bucking coils 334-339
'' series, regulation 345
Buckled battery plates 456-457-458
Buckling, meaning of 439
Buffer blocks, where used 622
Buick adjustment of transmission 670
'' '' '' clutch 668
'' carburetion heating method............157-179
'' clutch (see also Insert No. 1)..................665
'' clutch tool 742
'' Delco system 381-388
'' electric switch 378
'' engine (see also Insert No. 1)............44-109
'' gear shift 497

Buick ignition setting 109
" " timing of 245-309
" rear axle adjustment (also Insert).....676-677
" re-designing old car 762
" removal of rear wheels 677
" removing push rods 742
" size and type of battery 442
" "six" clutch ....Insert No. 1
" socket wrenches 592
" spark and throttle control....................496-497
" specifications 548
" steering device 693
" valve clearance, adjusting of..........109-94
" " grinding 742-683
" " timing 109
Building a four cylinder engine 62
" " garage for business..........596-597-598
" " " for home 619
Bulbs, (electric), size to use on leading cars......434
" (see lamps, electric) 432
Bumpers 17-511-514-736
" for rear of car 786
" how to straighten 731
Burner for Stanley steamer....................763-764
Burning connectors of battery 471-472
" point of oil 201
" strip for battery 439
Burnt bearing or bushing 643-201
Bushing a valve guide 634-791
Bushings, removing of 644-650-824
" for bearings ....641-643 to 645-203
Butterfly throttle valve 152-153-154-146

C

Cable or wire for starting and lighting..425-426-428-240
Cables for magneto 297
Cadillac adjustments, (ignition)....................182
" air compressor 562
" and Hudson Delco system (1914).........879
" axle shaft removal of 679
" carburetor 180
" chain adjustment 729
" clutch 40
" condensing device 780
" Delco electric system 896-182-133
" disconnecting battery 423
" electric system 182-133-396-542
" engine ....127 to 133
" firing order 181
" gear shift 133
" ignition timing 132-729
" (1914) magnetic latch 483
" radiator repair 714
" rear axle adjustment 674
" re-designing old car 762
" removal of rear wheels 677
" replacing silent chain 729
" spark and throttle control 496
" specifications 543
" test light for ignition timing..........729
" thermostat on cooling system..........180
" (1914) two-speed rear axle 488
" valve timing 108-729
" wiring diagram 133-396
Cadmium test of storage battery..........864D
Cage type valves, grinding of 631-91
Calcium chloride for non-freezing solution........193
Calipers ....,614-700
Cam and fly wheel, direction of travel 89
Camber of front wheels 683
Camping outfits 516-743
Cams and cam shafts..87-68-94-116-120-121-128-137-139
" how they tell order of firing....................120
" on interrupter 309-298
" quiet 99
Cam shaft, Cadillac engine 129
" " drive, leading engines 548
" " (6-cylinder) illustrated 121
" " overhead 90-136-109-911-912-916
" " relation to cam and valves..........120
" " removal of 650-853
" " setting, Packard 853
" type brakes 686
Canadian auto laws 524
Canal Zone laws 524
Candelabra screw lamp base....................433
Canned goods, when touring 520
Candle power and voltage of lamps....431-432-434-467
Cantilever springs 27
Canvas fenders for racing 816
Capacity of fuses 428
" of a pipe 539
Cape chisel 700
Cap screws 701
Carbide gas generators 437
Care of clutch ....661 to 668
Cardan joint, meaning of 582
Car lifting device 734
Carbon 202-623
" and spark plugs 283
" brushes on magneto 300
Carbon brushes used on Delco generator..........404
" cause of 202-623
" cleaning 624-625-726-727-610
" collection top of piston 652
" indications 625
" preventative 625
" relation to combustion 623
" " " lubricating oil 623-202
" removal, water injection 735
" removed, prices usually charged..........595
" scrapers 592-624
" where usually deposits 628
Carborundum cloth, valve reseating tool..........632
Carburetion, air washer for 828
" at night 585-168
" at sea level 168-585
" during cold weather 170
" kerosene difficulties 831
" Pitot principle 800-177
" water feed principle..........828-754-735
" principle of 142-57
" and spark lever 67-222
" simplified 144
" vaporizing 155
Carburetor acceleration 150-151
" adjusting 166-171-174
" adjusting screw 148
" adjustment for winter 170-158
" air control 170
" " regulator 159
" " type, disadvantage 150
" " valve 150-801
" " valve type 149
" attachments 158
" automatically operated needle valve....172
" auxiliary air 147
" back firing of 170-169
" Ball and Ball 864F
" ball air type 152
" Cadillac 130
" Carter 179
" compensator 182
" compensation jet type 149-151
" concentric float type 145
" dash pot 150-172
" double jet 148
" double type 754
" drips 580-585
" electric heating 157
" exhaust gas heating 157-170
" expanding type 149-151
" flange packing 159-164
" flexibility of control 150
" float 143-147-145
" float adjustments 160-166-167-163
" float chamber 147
" float-feed 141
" float level 147
" float valve tester 787
" flooding of 171
" for "V" type engine 171-182
" tractor engines 831-827-754
" Ford type 166-798
" freezing 754-158-585
" gaskets 164-169
" gasoline level 167
" heating methods...155-157-159-160-170-744
" heating method, home made 744
" heating mixture 159
" how to determine height of float.......167
" " " " " " gasoline ...167
" " " " size of 158
" Holley, kerosene 828
" Hudson 183
" idling 158
" if too large or too small....................158
" injection of steam 735
" intake manifold 159-164
" intake manifold heater 157-744-160
" Johnson 184
" kerosene and gasoline..........166-754-160-831-827-754
" Krebs principle 144
" leading types of 171
" loading up of 175-586-589-578
" main air supply 147-148
" manufacturers addresses 161
" Marvel 179
" Master 180
" Maybach principle 144
" mechanically operated needle valve.....174
" metering pin type 149-151-183
" Meyer 180
" mixing chamber 147
" mixture 168
" " at low speed and high speed...168
" " how to determine 585
" mixture how to test 169
" motorcycle type 845
" multiple jet 148-179-180
" old, how to increase efficiency..........744

Carburetor on the Dodge 178-733
" on the King 864F
" on the Overland 188
" on the Packard 855
" on the Studebaker 172-864F
" overloads 586-175
" parts of 145
" parts to adjust 166
" passage area, size of 158
" Pitot principle 177-800
" plain tube type 176-177-800
" principle 142
" priming rod 160
" Rayfield 151-175
" refrigeration 754-158
" Schebler 148-172-178-174
" side float type 145
" single jet 148
" springs 147
" spray nozzle 147
" Stromberg 176-178-184-927
" surface type 142
" temperature regulator 155-159
" tickler 145
" Tillotson 183
" throttle valve 148-152-153
" tractor engine 831-827-754
" troubles ....166-578 to 581-800-184
" used on leading cars 543
" used on two cycle engine....756
" valve springs 147
" Venturi 152
" warm air, how drawn in 159
" water injection 735-754-828
" why popping and back-firing....170
" with governor 747
" Zenith 180-182
Care of a car 505
" " " " daily, weekly, etc....510
" " battery 454
" " chains 18-749
" " clutch ....661 to 668
" " generator 408
" " magneto 297
" " starter motor (Bendix) 331
" " starting motor 407-408-331
" " storage battery 454
" " tires 565
" tests and adjustments, Delco system...397 to 406
Car, heating of 192
" overhaul 620
" skids 495-588-590
Cars no longer manufactured, where to obtain parts.547
Carter carburetor 148-179
" car friction disk type 47
" gasoline pump system....164
Carriage bolt 701
Case hardening 695-696
Cast aluminum 721
" iron, cleaning of 401
" iron welding 721
" steel 721
Castellated nut 701
Castor oil as a lubricant 582
Catalogues, where to obtain—see addresses....533
Caterpillar tractor 830
Cause of knocks ....635 to 639-580-591
" " loss of compression 628
" " " " power 626
" " mis-firing 735
" " noise in timing gear 583
" " piston ring troubles 656
" " tire troubles 566-567
" " troubles, how to reason out....576
Cell, meaning of 439
" connections of battery 443
" connector 439
Cells, dry 211-214-589
" for battery 445-439
" secondary 211-214-445
Cellular radiators 187
Cementing inner tube patch 569
Centigrade to Fahrenheit 540
Centimetre, what part of an inch....541
Centrifugal governor control of generator....334-351
" governors for engines 840
" pumps for circulation of water....187
" type speedometer 518
Chain adjustment 369-648-749-113-729-733
" adjustment, importance of....729
Chains, care of 18-749
" cleaning of 749-741
Chain drive, advantages and disadvantages.... 19
" drives 18-747-749
Chain hoist 605-615-617-618
Chains for tires (non-skid)....550-551-559-560
" how to store in car 590
" Morse 728
" on Overland engine 648
" roller type 18-749
" side to put on 551
Chains, silent 21-87-369-411-728-729
" silent, adjustment of..728-229-411-369-729-733
" solid tires 560
" sprocket 21
" tightener 648
" using oversize 590
Chalmers electric system 357-358
" firing order and valve timing....124-357-542
" gear shift 497
" "non-stallable" (former electric system).352
" rear axle adjustments....674-678
" removing timing gears 318
" spark and throttle control 496-497
" spark timing 357
" specifications 542
" "six-30" wiring diagram 357
" valve and ignition timing 318
" valve grinding 137
Chamois skins 602
Champion plug cleaner 592
Chandler gear shift 500-542
Change gear principle 12-51-48
" speed gears; different methods of connecting 13
" speed gears; purpose of 12
Changing gears 488-486-490-493-51-48
" " pointers on 493-488
" poles of a generator 421
Channel iron 710
Charge amount of generator average....371
" rate 439
Charges for demonstrating trucks....747
" for overhauling a car 595-794
" for oxy-acetylene welding 735
" for tire repair work 574
Charging action of battery 447
" battery after repairing 470
" battery, determining when fully charged.459
" batery, how to tell when needed....453
" battery, object of, simplified 447
" batteries, lamp resistance for....465-461-460
" circuit for battery 461-410
" rates for battery 461-467-459
" rates of generator, how to change...405-390
" storage battery from gen. on eng....337-410
" storage battery with generator....327-410
" 12 volt battery from 6 volt circuit....465
" outfits for batteries 462-464
Chassis, Locomobile 44
" of a truck 747
" of Studebaker and Hudson 204
" what consists of 7-10-15
Chauffeur's examination questions 534
" license 522-528
Checking magneto timing 318
" sheets, for garage use 606
" valve timing 118
Check sheet for repairman 740
" valve for two cycle engines 753
Chemical generator of electricity....210
Chevrolet adjustment of brakes and rear axle..672-671
" " " transmission 671
" clutch repairs 664-665
" electric system 364
" firing order 364-542
" ignition timer 253
" " timing 364
" spark and throttle control 496
" specifications 542
" valve timing, grinding valves....636
" wiring diagram 364
Chisels 709
Choking air supply of carburetor....159
Christensen engine starter 331
Chrome steel 731
Chuck for lathe 615
Circuit breaker 428-377-359
" " Delco 377
" " or interrupter of magneto....272-298
" grounding of 213
" high tension coil 229-231
" breaker troubles 377
Circulating pump 65-196
" " leaks 193-191
" lubrication systems 196-193
" splash oiling systems 200
" water pumps 187
Clashing gears in transmission 660
Cleaner, blow cock for 739
" for spark plug 593
" spray type for engine 631-740-594
" for wind shield 736-598
Cleaner for window 736
Cleaning a car 507-595-620-631-741
" and polishing, price charged....595
" brass parts 741-401-598
" brakes 683
" brushes for generator 406
" carbon 624-625
Cleaning chains 749-741
" commutator 406-404

Cleaning crank case 201-595-621
'' distributor 254
'' engine 201-621-594-740-491
'' engine, price charged 595
'' fenders 590
'' gas tips 486
'' glass 508-435
'' metals (various kinds)....................401
'' oil pump and pipes....................200-709
'' oil regulator 741
'' pistons 651
'' radiator 191-789
'' reflectors 435
'' spark plug 235-237-589-592-595
'' tank 740-744
'' top 508
'' transmission 671
'' upholstering 509
Clearance, of car 17
'' of piston 649-651-792-588-75-645
'' of piston ring gap 649
'' of valves 94
Cleveland tractor 830
Click in front wheel 681
Clicking of Delco driving clutch....................883
Climbing a hill 491
Clincher tires, attaching and detaching....................558
'' tire, will it fit a Q.D. rim?..........558-586
'' rim and measurements 551-554
Clock, for dash 849-511
Clockwise and anti-clockwise....................296-313
Closed circuit ignition system 242
'' and open circuit principle of ignition......243
Closing and opening of inlet valves 96
Clover leaf, meaning of 15
Clutches 37-661-931
Clutch adjustable pedals 662
'' adjustment of Borg and Beck.....42-43-668-842
'' '' '' Buick 665
'' '' '' Cadillac 40
'' '' '' Chevrolet 665
'' '' '' Dodge 666-932
'' '' '' Hudson 666
'' '' '' Overland 666
'' '' '' Reo 667
'' '' '' Studebaker 665
'' air or magnetic type....................481
'' brake 665-668
'' Buick ....Insert No. 1 & 665
'' cone-type 39-660-662
'' disk type 41-666-667-663-931
'' drags, cause of 661-663-580
'' dry disk type............42-50-668-842-932
'' expanding 39-662
'' for Delco motor 387
'' '' Delco generator 386-398
'' '' starting motor 341-351-690
'' grabs or is fierce 580-663-662-668
'' Hele-Shaw 40
'' how removed 662
'' how to use properly 661
'' importance of 493
'' ''in'' and ''out'' ....37 to 39-41-51
'' internal expanding 662
'' leather, best kind to use 661
'' leather oily, result 580
'' '' treatment of 660-661-664
'' '' worn 662
'' lubricated type 40-203-663
'' multiple disk 41-666-667-663-779
'' operation 39-661
'' overrunning principle 341-385-398
'' pedal 89
'' '' adjustment 662-665
'' relining 660-664-932
'' repairing ....660 to 668-932
'' roller type (starting motor)..........351-690
'' single plate.........41 to 43-50-663-668-842
'' slipping 661-668
'' spider 662-931
'' spring 661
'' spring compressor, Dodge....................932
'' spring tool, Ford 819
'' spring tool, Overland and Reo........647-744
'' springs, replacing of 663
'' ''thrown in'' and ''thrown out''..37 to 39-41-51
'' troubles ....660 to 665
Clutch, types of 39-38-40-42-661-779
Coasting 494
Coes monkey wrench 614
Coil and battery ignition 242
'' and spark plug troubles 283
'' condenser 227-228-245
'' four cylinder vibrator type....................226
'' high tension 218-219-220-221-231
'' '' '' as used with generator.....245-341
'' '' '' and low tension magneto 259
'' '' '' testing of..234-235-236-302-398-402
-710-253-416-418-245
'' ignition systems, disadvantages of 255
Coil ignition systems, general review of..........255
'' '' (Delco) 378
Coil jump spark 218-219-220
'' low tension type 215
'' low tension ignition 206
'' Master vibrator 232
'' non-vibrating 235 245
'' of magneto, how to test..........301-302-304
'' secondary of magneto 269-304
'' size wire used 240
'' testing of generator armature 402-406-410-424-418
'' unit 808-808
'' vibrator, explained 228
'' winding (primary) 215-221-245
'' winding partially short circuited..........286
'' wire for 428-240
'' with vibrator, disadvantages of..........255
'' with vibrator, timing of 315
Cold chisel 700
'' draft preventive 740
'' test of oil 201
'' weather precautions.....193-451-585-586-589-804
Cole-Delco, wiring diagram 392
Cole gear shift 499
'' spark and throttle control 499
'' specifications 548
'' valve tool 688
Color of smoke, what it indicates..169-202-652-580-588
Color of storage battery plates....................445-447
'' '' '' '' terminals 421
Collector ring for magneto 269
Collet, for die 704
Collision insurance 521
Combination pliers 614
'' switch, Delco 875
Combining magneto and coil ignition....................287
Combustion and spark, relation of 307-319
'' chamber 88
'' relation to time of spark....................307
Commercial cars and how to select............747-528
Commutator 61-225-84-242-222-227-325-407-805
'' and distributor 242
'' brush fitting and trouble........404-409
'' care of and greasy....................409-407
'' mica, how to undercut.......409-404-748
'' of generator 338
'' of generator, how to dress...409-406-748
'' or timer how helps control speed.....227
'' principle on electric motor.......323-325
'' relation to dynamo 227
'' repairing 409-404-748
'' sand papering of 404-406-409
'' segments 227-404
'' sparking 409-404
'' testing for roughness....................404-406
'' troubles, cause of....241-325-404-409-804
'' turning down on lathe....................404
Compass for finding N. and S. pole of magnets..303-805
'' how to use watch as 516
'' how shows flow of current....................221
Compensating gear (see also differential)....35-13-669
'' jet type carburetor 149-151
Compensator for over voltage protection..........428
'' for carburetors 182
Compressed air starter 322
'' air tanks 564
Compound armature 274
'' hand air pump 562
'' winding 332-333-335
Compression 61-219-307-627-640-793-817-790-909
'' advantages in overhead valve type....627
'' affects spark 817
'' altered by change of bearings.......648
'' average of engines 627
'' cocks 87
'' determined with throttle open.......627
'' effect and cause 627
'' kerosene used 828-627
'' knocks 638
'' leak between cylinder wall and piston 629
'' loss of 629-626-628-630
'' lower when kerosene 828-627
'' Packard 858
'' or relief valves 87
'' relation to gaskets 627-640
'' space in engine 627-793
'' stroke 57-116
'' testing of and gage......629-627-628-739
'' whistle 514-515
'' (air) for shop use 564
Compressor for air 564-562-553
'' for clutch springs.932-664-647-742-744-819
Compressometer 629
Concentrated sulphuric acid 448
Concentric float carburetor 145
'' piston ring 651
Concrete, how to mix 619
Condenser, defective 303-398-245
'' for coil 228-229-245
'' for magneto 269-273-303
'' for water, Cadillac 730-709
'' function of and on Delco coil.....229

Condenser, testing of 245-803
Condensing device for alcohol (Cadillac).........780
Conductors of electricity 206-207
Conduits ....426 to 428
Cone clutch principle and repairs......89-660 to 665
Conical type valve 92
Congested districts, meaning of 503
Connecting rod 63-75-643-645-85-646-837
" " alignment, testing of.646-649-733-659-837
" " bearings 73-641
" " bent, cause of knock..............659
" generator to battery 421
" " lower bushing 645
" " shims 641
" rods and pistons, lining up........659-646
" rods, require side play 645-646
" " yoked and side by side....75-127-129
" " "V" type engines 75-74-78
Connecticut ignition on Chevrolet 364
" ignition system; adjusting, etc...251 to 254
" shock absorbers 782
" thermostat 246-254
Connections of battery, miscellaneous..466-421-422-459
" " battery, how to make............428
" " battery, reversed 421-459
" grounded 209-218-240-425
" loose 241
" of cells 212-214-444-466
" " dry cells 207-209-214
" " magneto armature winding.......258
" " Splitdorf coils 228
" " volt-ammeter how to make.........414
" " of wire, how to make............240
" on distributor 295
" parallel 208-214
" series and series-multiple.....207-209-214
Connectors of batteries, burned and bolted........468
" for wires 428-240
Constant current or amperage regulation principle 843-845-925
" for horse power formula.................534
" or continuous current 211
" source of electric supply...........242-341
" speed drive of generator 334
Contact breaker box, how to install..............254
" " of magneto (see interrupter)........
" " or interrupter....242-243-225-259-304
" " Remy 298
" points (magneto) pitted.........298-234-304
Continental engine (see also insert No. 2).....71-544
Controller of electric vehicle..............476 to 478
Control of generator current................334-337
" " spark 305
" " speed of engine..................... 67
Constructing a garage 597-619
Conversion table, hundredths of inches to sixty-fourths 115
Conversions tables, miscellaneous................539
Convertible coupe, sedan and touring car......... 15
Converting inches into degrees............115-93-541
Cooking fire 516-520
Cooling a fire engine...........................587
" Cadillac system 130
" lubricating oil 201
" of engine 185-69-186-188-189
" of engine with kerosene (not advised)....585
" Packard system 860
" Renault system 186
" thermo-syphon 185
" troubles 189-191
" thermostat 191-130-860
Copper gaskets 607-717
" soldering 711-614-586
" wire as used with electric transmission..207-427
" wire terminals 609-427
Corbin and Brown speedometer.....................513
Cord type tire 550-559
Cork inserts for roller clutch...................690
Corrosion of battery terminals...................439
Cost of equipping machine shop 617
Cots for touring 516
Cotter pins 609-795
Counter-electro-motive force 899
Counter shaft 48
Counter sink, for brake lining 616-690
" balanced crank shaft 79-122
Coupe and Coupelet, definition of............... 15
Couple-gear gas electric truck 494
Coupling or junction box for wiring..........426-428
Coupling for trucks 561
Couplings for magneto 302
Coupling Oldham 302
Cover for radiator 188
Cracked battery jar 471-457
Cracked cylinder 580-713-193
" ball, how makes its presence known...... 36
" water manifold 715
Crane or hoist 605
Crank case 68-72
" " barrel type 62
" " cleaning of 201-595
Crank case depth of oil in.......................196
" " hot 580
Crank case six cylinder 121
" " wrench 738
" pin 77
Cranking by hand, proper hold and why......490-143
" current 387-400-327
" operation, Delco 386
" when touring 517
Crank shaft 77-63-122
" " alignment, test of 646
" " and cam shaft speed relation..........308
" " and connecting rod "V" type engine. 75
" " balanced 79-122-532
" " bearings ....72-203-532-640 to 647
" " bent 646
" " "built up" type 79
" " degrees of 77
" " drive from electric starting motor.324-326
" " removal of, Overland method.....648-647
" " scored 642
" " six-cylinder 123
" " stand 605
" " speed to distributor speed, 12 cylinder.135
" " "throw" 77
Crating a battery and automobile............478-509
Creeper for working under car....................604
Cubic inches, conversions of 539
" " of engine cylinder 539
Cumulative compound winding 347
Curb gasoline pump 602
Cure, as applied to vulcanizing..................564
Current, constant or continuous and flow of.......211
" how induced in primary coil............223
" how made to alternate..................267
" how intensified 214-215-219
" induced, meaning of 219
" indicator 370-410
" meaning of 221
" required for starting motor..........410-416
" regulation of 337-343-347
" secondary, meaning of 219
Curtain (top) glass 849
Curtiss airplane engine 921
Cut cylinders (see scored cylinders)...202-587-653-656
Cutler-Hammer magnetic gear shift................482
Cutting iron or steel with oxy-acetylene..........724
" gaskets 716
" keyways 708
" mica, on commutator 409-404
" off magneto ignition 275-299
" tire fabric 603
Cut-out adjustments (electric) 398-409
" exhaust (muffler) 84-732-608
" fails to operate.............409-422-406-410
" how to determine if working properly.....411
" mechanical type ....see insert
" not used on Delco 383
" on overland 359
" principle 344-337-342
" reverse current type 370
" tests 410-406
" testing with ammeter 410
" vacuum type 843
Cycle, meaning of 57-756
Cylinders 81-63-79-532
Cylinder, crack in 580-193-718
" cut repair 653
" degrees of 134
" en-bloc 81-83
" firing order of............116 to 120-542
" head detachable 137-80
" " replacing of 649-659
" lapping 649-650
" leaks 193
" offset 81-532
" painting 509-588
" raising evolution 134
" reamer 616
" reboring, reaming and grinding....658-654-792-813-616
" rotary type 136-138
" scored 201-202-650-653-587
" staggered 127
" types of 81
" welding 721-726
Cylinder types, advantages and disadvantages of...532

D

Daily attention to a car 510
Dampener (vibration) 728
Dash-board; how attached 7
" instruments leading cars...497 to 500-824
Dash lamp 433
" pot and metering pin................151-586
" " of carburetor 150-175-172-130
D. C. or double contact base for lamps............433
Dead axles 13-31
" short circuit 412
Decimal equivalent of fractional part of an inch.541-597
Decimeter 541
Decarbonizing chemicals 624-625
" outfit 727-624-625

Degrees.. 98-541
" converted to inches.....................314-115
" (Fahrenheit standard) of electrolyte......449
" minutes and seconds 93
" of crank shaft throws.................... 77
" of eight cylinder "V" type engine....... 70
" (setting of magneto) 311
" symbol of 541
Delco, address of 378
" armature winding 381-387
" automatic control for spark........376-388-384
" " spark and variable resistance.....384
" battery and coil ignition system............375
" brush and commutator trouble...............404
" Buick electric system 388
Delco-Cadillac electric system 396-182-729
" circuit breaker 377
" coil 378-245
" Cole wiring diagram.........................392
" commutator dressing of 404
" combination switch 375
" cranking operation 386
" cranking tests 400
" distributor and timer 377-132-378-245
Delco-Dodge wiring diagram 369
" driving clutch "clicking"....................383
" electric systems, adjustments................397
" field winding 381
" genreating principle 380-386
" generator, amperage of 390
" " charging rate, how to change....405
" " clutch 386-398
Delco-Hudson "six-40" electric system...........385
" " "super-six" wiring diagram......391
" ignition coil test 245
" " if fails 401
" " system, early form 374-375
" " timing 390
" lighting circuit tests 402-399
Delco-Light plant 824
" lubrication 397
" meshing gears 386
" mica protruding 404-704-409
" modern ignition 375
" motor clutch 387
" motor-generator brushes 404
" " -generator principle 386
" "motoring" the generator 399-386
" motor parts, how to clean 401
" " winding 381
" non-automatic spark electric system.........394
Delco-Oldsmobile wiring diagram.............393-394
" regulating resistance units, size to use.....397
" regulation methods 381
" relay ignition 375
" resistance units 246-378-381-388-397
" single wire or grounded system..............383
" spark lever position 377
" starting and generating system, principle of.379
" " operation 379-384-386-385-395-400
" test for "motoring" generator...............400
" tests miscellaneous 398-399-402-403
" third brush adjustment 405
" third brush regulation......389-405-386-393-396
" timer 244-245-377-132-378
" troubles 401
" variable resistance regulation...............392
" when motor fails to start................404-401
" why cut-out not employed.....................383
Delivery car, how to select......................528
Demountable rim with tire 552
" straight side rim....550-551-552-555-557
Denatured alcohol 193
Depolarizing, Bijur 857
Depolarizing generator 421
Depolarizer type switch 246
Depth of oil in crank case 196
Designs for old cars ....760 to 762
Desk for foreman 710
Detachable cylinder head 137-81-90-783
Diagnosing battery troubles......458-457-421-422-416
" magneto troubles 299-301-304
" troubles 576-577-416
Diagram of a typical electric system..............342
" " battery and coil ignition 245
" " Delco generator amperage 390
" " electric symbols 356
" " Ward-Leonard electric system....342-344
" " Westinghouse battery and coil ignition system 346-348-349
" " wiring of high tension coil...218-220-224-226-231-228
Diagrams of wiring, low tension ignition systems...215
Diameter and revolution formula.................617
" of circle (finding) 539
" " pulleys (finding) 617-563
Diamond point chisel 700-707
Die and tap sets 612-613
Dies and taps, explanation of.....704-612-613-795-796
Dies for threading small pipe.....................608
Diesel engine explanation 758-587
Differentials 35-13-669-32-673-674-678-932
Differential adjustments Timken rear axles.673-674-678
" adjustments, Buick and Dodge....677-932
" automatic action of 13
" how fastened to axle shaft...........669
" lubrication 205
" removal of 669-675-932
" " on Maxwell 675-676
" troubles 675-932
" winding on generator..................345
Different ignition systems, advantages and disadvantages 255
" ignition systems on one engine.........287
Difficulty in shifting gears, causes of............669
Digest of battery troubles 458-422-428
" " lighting troubles 419
" " troubles . . . .576 to 581
Dim lights 411-419
Dimming headlights 429-437-588-795
Direct current, explanation of.................211-257
" " generator 333-335
" " how obtained 387
" drive 51
Disadvantages of multi-coil ignition...............229
" " pressure and gravity gasoline feed.164
Disassembling batteries 468
" rear axles 673-678-932
Discharge, meaning of, relative to battery........489
Discharged battery, cause of 422
Disconnecting battery (see index, battery)....421-428
" generator 428
Dictionary 861
Disk clutch 41-666-662-931
" " adjustments and repairs..663-666-667-932
" " lubrication 203-666-667
" piston 75
Displacement of piston 538
" type armature 380
Distance of breaker gap on magneto..........288-298
" rods; definition of 21
" to set interrupter points, magneto.315-297-298
" to set timer gap 250-378
" to set spark plug gap 233-219-299-542-378-808
Distilled water 474-709
Distributor 232-245-269-296-806-813
" and armature, speed relation of.......808
" " commutator 242
" " timer 242-244-246-252-254-259
" " timer (8 cylinder)..................131
" " " (12 cylinder) 135
" " " driven from generator.......341
" " " shaft 247
" brush type 269
" (Delco) 131-374-377
" Dixie 293
" drive method on generator 341
" elementary principle of......................282
" gap, distance of 247
" gap type 247-269
" for a coil 232
" gear on magneto 272
" mica peep-hole 310
" of high tension magneto 269-262
" parts of magneto 270-275-297
" speed and connections.295-294-271-261-806
" wires, how to separate and protect....297
Divided exhaust (see also insert number 8)...... 82
Dixie breaker mechanism 298
" magneto (see also Insert)...........290 to 293
" magneto, motorcycle (Insert No. 3)....292-811
Doble steam car 765-757
Dodge adjustment of transmission............670-932
" carburetor 178-733
" cam shaft removal 650
" clutch adjustment 666-932
" disconnecting battery 428
" engine ....see Insert No. 2
" electric system 369-733-924
" firing order 369-542
" gear shift and lever controls................497
" generator chain, adjusting of.....411-733-369
" " gear puller 788
" ignition timing 369
" meshing timing gears 112
" oil (engine) adjustment.......................733
" oil for rear axle..........................205-932
" oil level in gearset 670-666
" rear axle 931-932
" socket and spanner wrenches 592-788
" spark and throttle control.................496-497
" specifications 544
" steering device adjustment 698
" "toe-in" of wheels 683
" third brush regulation.....................370-733
" truck 825
" valve guide reaming 634
" valve timing 114
" wheel puller 787
" wiring diagram and electric system..369-370-923
Dog clutch, where mostly used.................... 21
Dome lamp 488
Dont's and Do's, electrical.......................421

Dont's for drivers and repairmen............591-494
Door for repair shop or garage (self-opening)....780
Dorris rear axle adjustment 673
" specifications 544
Dort ignition timing 253
" specifications 544
Double chain drive 18-13-47
" contact bayonet base, for lamps..........433
"Double decker" motor-generator.................352
Double ignition system ....255-276 to 278
" gear drive (Bijurr) 328-857
" jet carburetor.............................148
" pole snap switch 480
" reduction starting motor drive............329
" spark in one cylinder 288
" system of ignition 255-287
Doble steamer 765
Double voltage battery system.............456-466
Drag link or tie rod 25-2
Draining oil from engine crank case.........491-201
Drawers for small parts 742
Draw-filing 643-708
Dressing commutator (see commutator).406-404-409-743
" breaker or vibrator points.......809-234-304
" for tops and upholstering............849-509
Drift or solid punch, some uses of........709-796-592
Drills 706-614-615
Drills in sets 614
Drill and tap sizes, table of...................703
" bench type 613
" chuck 706
" gauge, how to read 699
" how numbered and lettered 706
" how to select size and hole to drill...699-702-706
" how to sharpen or grind................707-616
" how to use 707
" jig for cotter pin holes...................739
" lubricant, kind to use 707
Drill press, chucks, lathes, etc. 615-618
Drilling clutch yokes 738
Dripping carburetor, cause of 580-585
" oil from engine and transmission....203-669
Drive, double chain 18
" pinion, purpose of......................13-5-19
" reduction (see also ratio of gearing),
18-22-770-781
" shaft 13-5-19
" shaft adjustment 673-674
" system 18-18
" systems for trucks 747
Drivers license 522
Driving a magneto 294-295
" " car 495-492
" " speedometer 518
" gear, where installed 19
" generator 841-386-338-351-369
" methods, electric starters 326
" pointers 505
" rules 501
" starting motor 324
" starting motor and generator 351-369
" the timer and distributor..............246-245
" when intoxicated 503
Drum armatures 256-323-325-332-335
Dry cell connections ....207 to 209-214
" " " (emergency) 241
" " " with Atwater-Kent systems..............249
" " disadvantages of 255
" " explanations of ....207 to 210-214
" " testing of 241
Dry cells used instead of storage battery......423-424
" " wiring two sets 217
" cure, meaning of 564
" disk clutch adjustment 668-842-666-932
Drying out a wet motor-generator 409
Dual engine valves 927
Dual tires 560
" ignition systems 255-262-263-276-277-287
Dump body for trucks 746
Duplex cables 240
" carburetors for "V" type engines..........182
" ignition system 288
Dusenberg valve principle and timing..........88-108
Dynamometer, fan type 536
Dynamo for ignition, advantages of 255
Dynamos 210-256-333-335
Dynamometer horse-power test 536
Dyneto electric system on Franklin 362

E

Easy starting in cold weather 586-155-153-489
Eccentric on a steam engine 52-764
Eccentric and concentric piston rings....651-655-654
Eclipse-Bendix inertia gear drive 326-331
Edison battery 475
Ediswan lamp base 433
Eight and twin six carburetors 182
" cylinder engines 127-532
" " engine, lap of power strokes..............126
" " firing order 131-542
" " magneto 298
" " relative position of pistons..............131
Eight cylinder "V" type engine, degree angle of.. 70
Eisemann interrupter 298
" magneto 285-288
" " on Locomobile 362
" " timing of 318
" " with automatic advance..............287-289
" pivoting advance magneto 288
Electrical lag 243
" symbols or signs 356
" test for horse-power 537
Electric arc burning outfit for battery.........471
" air compressor 563
" brake 479
" bulbs 484-437
" clocks 349
" connections 207-208-428
" current "alternating" 257-266
" " "direct" 211-257-209
" " how intensified 214-219
" " waves and impulses of.....................266
" equipment for shop 563
" generator 333-335-925
" " how driven 246
" " parts 212
Electric-gas car, Woods.........................479
" " " truck 484
" hand lamp 592
" heating of carburetor 157
" horn and tests 514-515-418-410
" ignition (see also "ignition")............206
" " how combined with generator....341
" " parts necessary 211
" " systems 213-243-255
" lamps, (also see lamps)................431-434
" lamp bases and sockets.....................432
" " candle power, amperage and voltage..432
" " current consumption 432-434
" " filaments 432
" " sizes used on leading cars...........432
" " Watts and candle-power....467-431-434
" " where used on a car...........................432
" light adaptors for oil or gas lamps.......430
" " wiring 430
" " dimming of 437-588-823-824
" lighting methods 431
" lights, source of power.................... 17
" motor driven truck 484
" " parts of 323-328-325
" " Westinghouse 328
" primer for carburetor 157
" spark for Doble steam car 765
" starting motors 328
" starter, Bendix 326-331
" " Bijur 328-857
" " Bosch 330
" " Rushmore 330
" " Westinghouse 328
" " motor, with reduction gearing.328-857
" starting and lighting systems of
leading cars.........356-543 to 546
" " motor, care and troubles of.331-407-408
" " motors 322-325
" " " types of 327
" supply, constant source of 242
" switches 213-327-329-248-277-427
" symbols 356
" system, Ents 352
" " Ford enclosed cars..........................864A
" " of motorcycles 848-811
" " Gray and Davis 351-354-355
" " of Cadillac 182-133-396
" " Pierce-Arrow 349
" " single, two and three unit....340 348
" " U. S. L. 353-347
" " Westinghouse 346
" systems, addresses of leading mnfg'r's.....373
" " advantages and disadvantages....255
" " ideal 255
" " of leading cars (see also
"wiring diagrams")....543 to 546
" testing outfit, how to make..424-418-304-864I
" thermostat 550
" troubles, how to diagnose and test....416-410
" vehicles and battery 476-477-478
Electricity, chemical generator 210
" how conducted 207
" how made to do work 211
" how transmitted 206
" mechanical 210-212
" nature and explanation of..................206
" static 297-585-162
Electrodes 214-215-218
Electrolyte 448-449-454-455-473
" freezing point 451
" gravity at end of charge...................461
" how mixed 448
" impurities, result 469-456-457
" level of 454-455
" spilled from battery 455-473
" tester 452-450
Electro-field magnets 256

Electro and permanent magnetic fields..825-323-335-212
Electro-magnetic gear shift....329-330
Electro-magnet recharger....303-807-819
Elementary principle of high tension coil....221
Element, of storage battery....445
Elliptic springs....27
Emergency brake and clutch pedal....6-485-490-665
" rim....551-552
" stop....489
Emery cloth valve reseating tool....682
E. m. f.—electric motive force (see also volts)....207
Emptying oil from barrel....730
Enameled parts, cleaning of....401
En-bloc cylinders....81-83
Enclosed valves....92-785
End play in transmission....669
Engineers wrench....611
Engine, aero (see also supplement page 900)...757-138
" adjusting....595-620-837
" advantages and disadvantages....532
" assembling of....62-636-648-838
" back fires....580
" balks....299
" bearings....72-640-648-641-837
" " testing and fitting....507-647-837
" Buick (see Insert No. 1)....44
" Cadillac....127-128-133
" cleaning....621-491-594-740
" compression—see compression.
" crankcase....72
" crank case hot....580
" crank shafts....77-112
" cold weather pointers....170
" continues to run....586
" Continental (see also Insert No. 2)....71
" control of speed....67
" cooling....185
" Curtiss....921
" Doble, steam....765
" does not deliver full power....579
" Dodge....see Insert No. 1
" double opposed....12
" draining oil....491-201
" Diesel type....757-758
" Dusenberg, valve timing....108-88
" "dual" valve....927-109
" eight cylinder....127
" essentials before it will run....576
" external combustion type....53-763 to 765
" fails to start....408-578
" fires irregular....300
" (Ford) (see Insert No. 2)....784
" (Ford) lubrication system....197-772
" for tractors and trucks....758-747
" four cycle, and the first 4 cycle engine..57-581
" four cylinder....63
" with four valves ("dual" valves)....109-927
" Franklin (see Insert No. 2)....189
" Golden, Belknap and Swartz....188
" Gnome....138-910
" Hall-Scott....913
" Haynes....121
" heating....189
" Hispano-Suiza....918
" how to lift from frame....605-797
" how to start and how to crank....153-143
" idling....153
" inspection and adjusting of....595
" internal combustion....755-53
" Knight type....139
" knocks....580
" lack of flexibility....578
" lap of power stroke....126
" Liberty....933
" leaks oil....581
" loads up....578-589
" loping....169
" lubrication....196 to 205-595-772
" Lycoming....71
" make used on leading cars....543 to 546
" makes hissing noise....580
" manufacturers, addresses of, Insert No. 2.. 71
" marine....755
" misses at high and low speeds....299
" misses at all speeds..579-804-806-236-237-170
" missing with spark retarded or advanced..298
" motorcycle....76-755-843
" multiple cylinder (how suspended)....11-12
" opposed type....70
" overhead cam shaft...137-911-912-914-916-109
" " valve type....90-85-109-921
" overheating of....189-319-579-583
" Overland....647
" Packard....851
" Pierce-Arrow....927
" painting of....509
" parts....72
" priming of....153
" racing of, damages bearings....203
" rating, "25-35," meaning of....583
" rotary cylinder; rotary valve....136-138
Engine runs slow and pulls hard....159-171
" "running in"....203-489-507-735-643
" " " after overhauling....735
" " " when new....507-203
" runs after switch is off....408
" " smoother at night, cause....585-168
" " well but car drags....580
" Rutenber....Insert No. 2
" single acting....55
" " cylinder type....70
" (single cylinder) where placed....11
" six cylinder....123
" sixteen valves....109-916-791
" sleeve valve....136-140
" specifications of leading cars....543 to 546
" speed, how controlled....158
" speed, how to tell....823-700-536-921
" speed relation to car....537-538
" stand....605-712-742-648
" Stanley steam....763-764
" starters, electric....326-331-832
" starters, motorcycle....844
" starters, mechanical, etc....321-322
" starting by "choking" air....159
" starting, if crank is lost....591
" " of....65-300-487-489-59-143
" " on ignition....321-282-832
" starts but misses and difficult to start.578-300
" starts but "pops" and "sneezes"....578
" starting with switch open....489
" steam....757-52-763 to 765
" stationary....757
" stopping of....489
" " fill cylinders with gas....300-489
" stops suddenly or slowly....578
" side valve type vs. overhead type....532-627
" Studebaker....71
" Stutz racing....108-109
" testing stand....744
" testing compression of....629
" tractor use....832
" truck use....833-838
" troubles....578 to 581-800
" "twelve" and "twin-six" meaning of..53-134
" "twin two" type....587
" two cycle....756-757
" two cylinder wiring diagram....231
" types of....70-71
" used as brake....583
" uses too much oil....584
" valveless type....757
" valves (see valves)....89
" vibrates, cause of....584
" Waukesha....833
" Weidley....136
" what is necessary before it will run....206
" where located....11
" will not crank, lamps burn bright....457
" " " pull....578
" " " stop when switched off....580
" Wisconsin aviation....911
" with good compression....629
" why loses power....626
" why necessary to start it....59-148
" why runs better at night....585-168
" why racing type 4 cylinder....587
English-French Dictionary....898
Entz electric power transmission....480-481
" " system....852
Equalizer for brakes....30-204
Equipment for blacksmith shop....615
" " machine shop....617-618
" " touring....516 to 520
" necessary and desirable for car..10-511-515
" of a repair shop and a garage....599-600
Erbswurst, meaning of....519
Esterline generator....832
Ether and gasoline....809-585-586
Ever-ready starter....322
Examination questions for chauffeurs....524
Examples of valve timing (see valve timing)...108-109
Excess of oil, remedying with piston....652
Exhaust and inlet valves....91-65-609
" "cut-out"....84-608-732
" heating of carburetor....155-157-159-744
" manifold....82-157-159-164
" of Cadillac....130
Exhaust pipe and muffler....84-12
" " over-heats....580
" pressure lubrication....195
" racing car....761
" smoky, cause of (see also "smoky exhaust")....202-169-656-588-580-652
" stroke....57-61-116
" valves....89-65
" valve, mercury cooled....824
" valve, opening and closing....96
" whistle....514-732
Expanding clutch....39-662
" type carburetor....151-179
Expansion of piston....65

Explosion, missing of 236-237-804-806-578-579
Exide battery 446
Extension tank on radiator 190
External combustion engine 58-764-765
" contracting brake 80-684
" short circuits (battery).................456
" shunts, for Volt meters.................414-416
"Extra Ext" spark plug 288
"Ezy-out" stud remover 709

F

Fabric of tires 565-566
Fahrenheit-Centegrade conversion table.................540
" thermometer (special scale) 451
Fan adjustments 191-788
" belts 198
" propeller type 198
" type dynamometer 536
Fans 187
Faure battery plates 440-445
Feet, symbol of 541
Fender cleaner 590
" canvas, for racing.................816
" straightener 731
" bent; how to straighten.................745-731
Few words to one starting in Auto business......583
F-head cylinders 81
Fiat specifications 544
Field circuit, shunt 400
" coil test 408
" core 323-325-335
" electro-magnetic 325-328-335-212
" magnet weak 412
" magnets 257-323-325-328
" " electro and permanent....256-332-335
" of a generator.................212-325-328-335-257
" of a permanent magnet (field of force)..266-267
" winding, Delco 381
Fields, electro-magnet 212
" multi and bi-polar, etc.................328
" permanent magnet 212
Fierce clutch ....580-661 to 668
Files 614
File for dressing platinum points.................284-809
Filaments, electric lamp 432
Filling gasoline tank 162
" plug of storage battery 439
" rods 719-721
Filing a bearing cap 648
" a piston ring 657
" draw method 708-643
Filter for oil 602-603
Finding compression stroke 120-320-116-117-57
" size pulley to use 617
" the grade of a hill.................589
" poles of battery 452
" poles of magnets.................303-806
" positon of piston.......114-320-310-105-836
Fire and gasoline 161-506
" extinguishing methods 602-161-506
" for baking 516-520
" " cooking when touring 516-520
" insurance 521
Fire-plug, parking near 503
Firestone rim, demounting and mounting.................555
Fire truck engine, how cooled.................587
Firing order of leading cars.................117-542
" " six cylinder engine 124-125
" " three cylinder engines 117
" " to determine by position of cams......120
" " (Packard) 856-135
" " twin motorcycle engine 846
" " twelve cylinder 134-135-856
First auto race and first auto show.................581
" change of gears 12-51-488
" year lathe work, (publication).................617-743
Fitting a clincher bead tire to a Q.D. rim.......558
" and cleaning brakes.................686 to 690
" a plain bushing to connecting rod...648 to 645
" brushes on generator 403-404
" electric horn to car 515
" exhaust "cut-out" 782
" exhaust whistle 782
" main and connecting rod bearings...648 to 647
" rings to cylinder 657
" " " grooves of pistons 659
" " " piston 658-659
" shock absorbers 732
" up a garage and shop.................599
Fittings for gasoline pipes 608
Five bearing crank shaft vs. three bearing........531
Fixed spark 307-311
Fixtures for repair shop 599
Flame test of cylinder for missing.................287
Flange gaskets 717
Flanging tubing 713
Flash test of oil 201
Flat of thread, meaning of 702
" wrenches 611
Flexible shaft of speedometer 513
Flexibility of control of carburetor.................150
Flooding of battery 439
" of carburetor 171
Float adjustments 145-166
" feed carburetor 141
" level 147
" " of Master carburetor 168
" " " Rayfield carburetor 167
" " " Schebler carburetor 168
" " " Stromberg carburetor 167
" " " Zenith carburetor 181-182-168
" of carburetor 143-145
" valve mechanism 145
" " tester 737
Floating axle, advantage of 582-31-33-669
" storage battery on the line..........334-337
Floor of garage, concrete 619
Flow of current explained 209-211-221
" " " in magneto 267
Fly wheel and cam gears, direction of travel...... 89
Flutes 704
Flux for welding 719-721
" or electric field of force.................267
Fly wheel drive method of motor generator........338
" " " starting motor 324-326
" " generator of current 265-347-353
" " indicator 114
" " knocks, testing 638
" " marking of degrees 107
" " purpose of 55
" " motor-generator (U. S. L.).................358
" " valve timing marks 104
Focusing headlights 433-435
Following tap 704
Foot brake pedal 485-665-662-6
Forced draught cooling system.................189
Force feed cooling system 185
Force feed lubrication 198-859
Ford carburetor (see Ford Supplement)160-798-799-754
" clutch spring compressor 819
" control levers 490-777
" cylinder—how much can be bored......792-813
" electric system, enclosed cars.................864A
" engine,.................see also Insert No. 2
" engine lubrication system 197-772
" engine in boat 825
" engine troubles 800-790
" headlight control 824
" ignition timing 804-316
" index 767
" kerosene carburetor 160
" firing order 784
" light wiring diagram 803-430-812-864B
" magneto 265-805
" magnets, how placed 588-805
" piston ring compressor 659
" ratie of gearing 780-781
" rear axle stand 744-797-824
" spark and throttle control 496-771
" specifications 766-544
" starter 322-864A
" supplement 767
" tractor and truck 826-825
" valve spring compressing 633
" vibrator points, dressing down.................284-809
" wrist pin 73-74-786
Forge, portable blacksmith's 615
Formula, finding speed of car.................538
" horse power 535
Forming plates of battery 447
Four cycle engine, first 581
" " principle 57
" cylinder engine, assembling of.................62-63
" " " lap of power strokes......126
" " " magneto 306
" " " why does not fire 1, 2, 3, 4.119
" " engines vs. "six" and "eight".....532
" ignition systems on one engine.........286-287
"Four-in-one" tire tool 568
Four speed gear shift 490
" speed transmission 47
Four strokes of piston 57-116
" wheel drive 484-748
Frame, how suspended 11
" how to straighten 731
" main and sub 11-
Franklin aluminum piston 63
Franklin carburetion heating method.................157
" cooling system and dashboard......189-49
" engine (see also Insert) 1
" spark and throttle control 4
" specifications 54
" wiring diagram ....
Freezing carburetor 585-158-75
" point of alcohol, kerosene, gasoline, water.5
" point of electrolyte in battery.................45
" " " gasoline 5
" " " water 48
" preventatives or solutions 1
French-English Dictionary ....

Freshening charge 489
Friction disc transmission 47
Front axles 81-680
'' axle, bent 584
'' axle, component parts of.......................... 24
'' wheel adjustment 680-681
'' '' why one travels further than the other 28
'' '' '' run free 13
'' '' '' tendency to turn to right...... 28
Frosting headlights 588
Frozen circulating water 193-579
Frozen radiator, how to thaw.........579-788-193-800
Fuel feed methods 163-164
'' system of steam cars 764-765
'' '' what consisting of 163-7
'' used on stationary engines 757
Full floating axle adjustment.........669-673-677-932
'' force feed oiling system 199
'' floating rear axle 33-532-669-931
Fullers earth for clutch 660
Fuse 428-412-417-348-783
'' block 428-348
'' blows or melts, cause....428-412-415-517-419-420
'' capacities and testing of 428-418

G

Galvanometer 267
Gang switch 426
Gap distance to set distributor.........................247
Gap of spark plug 218-219-233-287-542
'' '' '' '' for magento 298
'' '' '' '' if too wide 238
'' to set spark plugs and interrupter points....542
'' type distributor 247-269-261-312
Garage 597
'' and repair shop fixtures 599
'' and repair shop prices for storage........599
'' building, how to construct .....596 to 598-619
'' derivation of 582
'' for home, how to construct 619
'' gasoline supply of 599-602
'' heating of 598
'' lighting of 599-600
'' money making additions to...........601-610
'' office 599
'' 28 car capacity 599
'' wall, how to white wash 786
'' wash rack 605
Garford speedometer 518
Gas burning outfit for battery connections........471
'' blow torch 696-472-720-735
'' electric truck 484
'' filled lamps 432
'' generators 436
'' generators, non-freezing solution for.....193-438
'' knocks, meaning of 638
'' lamp adapters, to change to electric........480
'' lighting 437
'' producer 757
'' starter (for engine) 322
'' tanks and where to obtain..........436-438-725
'' test for leaky radiators...........................715
'' tips 436-438
Gaskets 716 717
'' and compression relation 627 640
'' assorted 607
'' copper 607-717 239
'' for carburetor 164-159-607-717
'' '' spark plugs 239-607-717
'' '' water head of cylinder 192
'' (thick) to relieve compression...........640
Gasograph 823
Gasoline 158
'' and air 150-151-142-169
'' '' fire 161-506-602
'' blow torch 735-711-712
'' boiling and freezing point......................585
'' consumption (see also Ford Supplement)..585
'' engine, explanation of 53
'' fails to reach carburetor........................580
'' feed, different methods 7-163
'' fire, how extinguished 506
'' freezing point of 585
'' fuel feed systems 164
'' gauge 514-823
'' how made 158
'' how drawn into cylinder 148
'' leaks 193-712
'' level in carburetor 167
'' low grade vs. high grade.....155-158-161-585
'' needle valve automatically operated......172
'' '' '' for carburetor 148
'' '' '' mechanically operated 174
'' old and stale 163-590
'' or kerosene for cleaning......621-740-594-491
'' pipe break, how to mend 162
'' pipe fittings 608
'' priming methods 153-156-157-821-801-823
'' pressure gauge 199-854-824
'' pump, curb type 602
'' pointers for speed and power.....809-585-586
'' storage tank 602
Gasoline supply of garage 599-602
'' system, Packard 854
'' tank gauge 514-824
'' tank on car, where placed.......................161
'' testing of 161-740
'' to strain 161
'' troubles 161-162
'' vaporizing of 155
'' volatility of 158
'' vulcanizer 570
'' water in 161
Gassing of battery 439-447
Gate or selectors for gear shifts 490-49
Gauge for oil, does not show pressure.........581-199
Gauges for compression 629-739
'' for drills, how to read...........................699
'' '' gasoline tanks 514-801-823
'' '' oil 199-200
'' '' oxygen and acetylene tanks..................720
'' '' reading atmospheres and pounds...436-438
'' '' screw pitch 700
'' '' steam car 764
'' '' thickness 697-699-94
'' '' tires 568
'' '' wire 700
Gear box alignment 782-749
'' '' how supported 5
'' boxes (see transmission) 45
'' changing 18-486-488-490-493
'' '' lever, position of........49-51-490-13
'' puller 606-729-737-788-748-302
'' ratio 22-588-12-294-781
'' '' leading cars ....543 to 546
'' '' transmissions 669
'' shift, army truck 490
Gear shift, Buick 497
'' '' Cadillac 188
'' '' Chalmers 497
'' '' Cole 499
'' '' Dodge 497
'' '' Haynes 499
'' '' Hudson 497
'' '' Hupmobile 499
'' '' levers, ball and socket......49-50-666-490
'' '' levers, gate type............................49-490
'' '' levers, sector type 46
'' '' lever systems 49-485
'' '' lever movements, different cars..490-497-542
'' '' magnetic 482
'' '' Marmon 499
'' '' movements of various cars.....................542
'' '' Overland 49
'' '' Pierce-Arrow 490
'' '' S. A. E. standard 490
'' '' Studebaker 499
'' '' Willys-6 499
'' '' Willys-Knight 499
'' tooth hardening 723
'' type oil pump 199
Gears, bevel, helical, skew, spiral, spur.........21-35-89
'' cam and magneto drive 885
'' how to remove 802-729
'' of engine, how marked 835
'' remeshing on "T" head engine....................106
'' remeshing timing gears......87-111 to 118-316
'' '' '' (Buick) 109
'' removing '' (Cadillac) 729
'' '' '' (Chalmers) 318
'' worm drive 21-35-750
Gearsets, (see transmission) ....45 to 49
Generator 210-333-335
'' amperage, Delco 390-387
'' and battery connections..........421-410
'' and lighting wire, size to use...........428
'' '' motor combined 336
'' '' '' how located on one engine..188
'' '' timer, how combined 246
'' armature of 212
'' armature tests (see "generator troubles") 402
'' autolite 358-364-409
'' brushes, care of.........................408-404-406
'' '' how to fit 404
'' chain, tightening of....411-728-729-369-733
'' changing poles of 421
'' Chalmer's non-stallable engine.........352
'' charging rate, how to change..405-925-358-364-409-733-369
'' clutch (Delco) 386-379
'' current, control of 334-337
'' connections to battery 421
'' drive through transmission.....................336
'' driving methods 336-338-341-351
'' fails to generate full output.409-410-416-923
'' field 212-332-271-403-406
'' field coil test 403-416
'' fly wheel type 265-347-353
'' for gas 436
'' for ignition, advantages and disadvantages 255
'' gear puller 788

Generator grounded 412
" ignition from 841
" parts 212-850
" principle of 332-333-335
" regulation 337-342-345-925
" Remy 850
" 6 volts charging a 12 volt battery....363
" speed and amperes 390-410
" system, meaning of 489
" terminals 209-212-423-424
" tests 416-410-411-409-402-403-424
" valve (fuel) 141
" voltage, how to test....414-410-416
" weak field magnet 412
" when disconnecting 428
" windings 332-333-335-343-345-837
Generating alternating current 257-267
" electricity 210-211-212-333-267
" principle, Delco 880
Glass polish 508
Glass for top curtains 849
Glare lens 433-429
Glossary, of storage battery terms....439
Glycerine and alcohol 193
Gnome engine 188-910
Golden, Belknap and Swartz engine....120-188
Goodrich tire gauge 568
Governors ....153-154-840 to 842
Governor, centrifugal 154-840
" control of electric system....847-351
" " " generator (output)....851
" for automatic spark 248-249
" action of spark control....246-249-383
" on Waukesha truck engine....835
" mechanical ....see insert
" water type, formerly used on Packard...154
" for stationary engines 757
Grabbing clutch 580-668
Grade, how to find 539
Grade meter 17-511
Grams to ounces 539
Granitoid, how to mix....619
Graphite-pile regulator resistance (U. S. L.)..847-358
Graphite, use of 205
Gravity, meaning of 439-447
" adjusting of battery 471
" at end of charge 461
" feed method of lubrication....196
" testing of battery 450-451
" too low or too high....458
Gray and Davis electric system (governor).851-354-355
Grease cups, sizes of 608
" for gear case 208
" gun, Townsend 592-622
" spots, removing of 507-509
Greasing and oiling a car....203-204-621-622
Grid for battery plate 439-445
Grinding valves, meaning of....91
" and reseating valves 630-632-94
" cage type valves 91-631-633-742
" cylinders 658-616
" leaky carburetor needle valve....167-585
" platinum points 284
" valves, Buick 633-742
" " different types 91
" " in detachable head 636-187
" " purpose of 92
" " on overhead valve engine....187
" " on Weidley engine 187
" " price charged 595
" wheel 740-632
" " on lathe 735
Ground connection of battery 421
Ground tests (see "testing for grounds").416-403-402
" wire 237
Grounded connections 209-421
" generator, causes of 412
" " coil test (see testing coils)...402
"Grounded motor," wiring plan (G. & D.)....355
" return wire 425-426
" switch" wiring plan (G&D)....355
" terminals of generator 212
Grounding coil circuits 229
" positive or negative circuit....213-421
" storage battery terminals....421
Grooving oil channels in bearings....640-644-208
"G R N D" abbreviation, meaning of 218
Gudgeon pin 643
Guide book for touring 520
Gummed piston rings 656-628

H

Hack saws 614-617-739-710-718
HAL, rear axle adjustment 678
" specifications 544
Hall-Scott engine 913
Hammers 614
Handbrake 28
Hand electric lamp 592-740
" oil pump for lubrication....197-814-816
erated horn 514-515
Hand and automatic spark control....246-249-289
Hardening steel 695-696
Hard solder 711
Harley-Davidson motorcycle (Insert No. 3)....843
Hartford electric brake 479
" shock absorbers 26
Haynes cam shaft 121
" crank shaft 122
" engine 121
" gear shift 499
" firing order 542
" ignition timing and electric system....373
" spark and throttle control 499-496
" specifications 544
" wiring diagram 378
Headache, curing of 589
Headlight control of, Fords....824
" courtesy on the road....504
" current consumed 483
" dimming of 429-437-588-795
" focusing of 433
" removing door of 437
Heater, gas 696
Heat proof paint 509
" treating steel 696
Heating carburetor 157-155-159-744
" " old type 744-170
" a garage 598
" a car 192-194
" (excessive) of engine 189-319-579-583
" water 187
Height of gasoline in carburetor 167
" " water in radiator 185
Helical gear, definition of 21
" drive gears, adjustment of 932
Hele-Shaw Clutch 40
Hex. of S. A. E. spark plug....612
High altitudes, effects on carburetion....168-582
" carbon steel 721
" gravity gasoline for priming....156
" mica on commutator 409-404-743
" or "third" speed 51
" tension armature 268
" " coil 218-219-220-231
" " " and battery system 242
" " " " low tension magneto...259-260
" " " circuit 229-231
" " " elementary principle of....221-231
" " " non-vibrating 245
" " " principle of 221
" " " winding of 219
" " " wiring 220-224-226-228-229-231
" " distributor, elementary principle of 232-260-261
" " ignition systems 213
" " magneto 269
" " " armatures 274
" to low gear 51-486-488
Hill climbing 491
Hinged connecting rod 643
Hints on locating Delco troubles....401
"Hit and Miss" governor 757
Hispano-Suiza engine 918
Hissing noise 580
Hoffeker speedometer 513
Hoist, chain type 615
" crane, for repair shop 605
" hydraulic 746
Hold down clips, for battery 439
Holley kerosene carburetor 827
" tractor vaporizer 827
Home garage, how to construct....619
" made battery charger 460-464-466
" made wash rack....605
Honey-comb radiator 187
Holt caterpillar tractor 830
Hook rule 700
Horn brackets and handles....515
" bulb type 515
" electric 514-515
" how operated and adjusted....514-515-418
Horse power abbreviations 535
" " electrical test 536
" " table, S. A. E. 534
" " test, dynamometer 536
Hose clamps 608
" for air lines 563
" for cooling system 193
" for radiator 608
" for testing for valve leaks 629
" for water, rotten 193
" radiator, keep oil off 622
Hot air attachment for carburetor....160-159
Hotchkiss drive 22
Hot crank case 580
" pin manifold 160
" spot heating carburetion mixture....157
" water heating for carburetor....155-744
Holmes air cooled car, address of....Insert No. 2
" weather tire inflation....553
Hound rod, where used 82
How to case harden steel....695-697

How to clean various parts of car............507-508
" " construct a garage for home use 619
" " " a garage for business....596 to 598
" " determine the poles of a storage battery.212-452
" " " size pulley to drive air compressor.568
" " diagnose troubles 576-577
" " drill 707
" " drive a car 501-485
" " file 708
" " find degrees 541
" " " a grade 539
" " " horse-power ....535 to 537
" " " piston displacement 538
" " " proper size wire to use...........427
" " " the poles of the battery..........452
" " " size pulley to use 617-568
" " " speed of car 588
" " " thousandths part of an inch........541
" " " wheel load of tires 554
" " fold an inner tube 568
" " keep snow from wind shield..........508
" " make gaskets 716-717
" " " a magnet re-charger 804
" " overhaul a car 594
" " read a drill gauge 699
" " " micrometer 698-699
" " " taximeter 537
" " run a lathe 743-617
" " select a car 527
" " sell supplies 595
" " ship a car by freight...............510
" " solder 711
" " start a car 486
" " start engine 487
" " start into the automobile repair business...593
" " steer a car 493
" " time valves 95-886
" " use a blow pipe torch...............735
" " use brakes 494-491-492
" " " a metal saw 713
" " " taps 705
Hub caps, tightening 681
Hudson and Cadillac 1914 Delco system.......879
" carburetor 188
" chassis 204
" clutch adjustments 666
" dashboard 498
" disconnecting battery 423
" gear shift 497
" ignition timing 390
" lubrication chart 204
" oiling system and adjustments....198-200-694
" radiator shutter 187
" rear axle adjustment 674
" re-designing old car 762
" "six-40" Delco system 886
" "six-40" wiring diagram (Delco)..........882
" spark and throttle control 497-496
" specifications 544
" starting operation 885
" "super-six" wiring diagram 891
" valve cap wrench 738
" " timing 108
Hupmobile dash board 498
" firing order 360-542
" gear shift 499
" ignition timing 360
" re-designing old car 762
" spark and throttle control..........499-496
" specifications 544
" starting motor clutch (repair)...........690
" valve timing 588
" wiring diagram 360
Hundredths part of an inch.........115-541-697
Hunting link, silent chain 728
Hydrant, parking near 503
Hydraulic hoist 746
" type speedometer 518
Hydrogen flame 489-725
" generator 439
Hydrometer 439-451-452
Hydrometer for battery, why necessary.......447
" for testing non-freezing solutions......193
" tests for battery trouble 457-450
" how to read 451-452
" readings, when to take 451
" syringe 439
Hydrometers, types of 451

I

I-beam 710
Ideal electric system 255
Idling of engine 153
Igniter 215
Ignition 206
" adjusting timer 245
advance, testing of 817
advance, meaning of 68
advancing and retarding of....68-227-246-819
Ignition and carburetion, elementary principle of.60-69
" " generator combined 341
" " valve timing of Chalmers................318
" Atwater-Kent 248-250
" automatic advance 246-249
" Bosch magneto 268-288
" coil condenser 228
" " Delco 378
" " distributor 282
" " explained 215-219
" " master vibrator 282
" " tests 234-235-236-249-253-398-402-710-302
" current consumed, Delco 400
" Delco early form 374-375
" Delco on Cadillac 182-183-729
" fails suddenly 300
" for Marine engines 755
" (four cylinder) how used with coil.......226
" from generator 341
" high tension coils...........218-219-220-231
" high tension magneto 269
" if fails (Delco) 401
" Locomobile 362
" low tension 260
" " " coil 206-215-217
" " " magneto 257
" " " " and high tension coil..260
" magneto 268
" " installation (see also magneto) 295-266
" multiple cylinder using make and break...260
" or spark lever 67
" on stationary engines 757-215
" principle 206
" resistance unit 378-347-246-381-383
" retarding and advancing of...227-68-246-319
" setting, on Buick 109
" single spark 243-250
" single, dual and double...................276
" spark, parts necessary....................211
" starter 321-325
" starting engine 321
" storage battery 210
" succession of sparks 248-250
" switch, testing 253
" systems 218
" system, battery and coil.............242-287
" " close circuit principle 242
" " Connecticut 251-254
" " double 255-287
" " dual 255-262-268-287
" " former method used on Packard..263
" " ideal 255
" " "make and break"................214-216-217
" " modern battery and coil...................287
" " open circuit principle 242
" " Packard 856
" " Remy 251-318
" " Splitdorf and Michigan 262
" " synchronous 232
" " two-spark and two-point..277-283-284
" " Westinghouse 251
" systems, advantages and disadvantages....255
" " a review of 255
" " combining into "dual"&"double"287
" " dual and double 255
" " four on one engine 286
" " high tension 218
" " low tension ....218 to 218-260
" " used on leading cars......548 to 246
" " using battery to start on and dynamo to run on............217
" testing ....235 to 237-710-739-744-416-241-304-302-301
" " for amount of advance of spark...308
" time of 68-308
" timer, adjustments of 247-254
" " and distributer 242-259-244-252-245-246
" " Chevrolet 253
" " Delco 245
Ignition timer, Dort 253
" " and distributor, drive methods..246-245
" timers, Pittsfield, Philbrin, Rhoades, Bosch.252
" timing (see setting and timing)....305 to 320
" " Atwater-Kent 250-810-316
" " Atwater-Kent on Ford........810-316
" " Bosch dual 312
" " Buick 390
" " Cadillac 132-138-729
" " Chalmers 357
" " Chevrolet 364
" " coil and battery 315
" " Delco 390
" " Dodge 369
" " Ford 316
" " Haynes 378
" " Hudson 390
" " Hupmobile 360
" " King 360
" " leading cars 542
" " low tension 8

Ignition timing magneto 310-312
" " make and break 815
" " Maxwell 367
" " Oakland 890
" " Overland 359
" " Packard 850-856-135
" " Pierce-Arrow 496
" " Reo 378
" " Saxon 364
" " sleeve valve engines....136-139 to 140
" " Studebaker 366
" " verifying of 817
" tractor engine 832
" troubles ....238 to 237-241-300
" two sparks 277-283-284
" use of dry cells instead of storage battery 423-424
" vibrator coil 225-226
" Westinghouse 348
" wipe spark 215
" wiring diagrams, low tension 214-216
" wiring of high tension coils 229-231
" wire and size to use....240-425-427
" without a spark 758
I-head cylinders 81
Illinois tail light law 857
Impedence, meaning of 378
Importance of the clutch 493
Improved rings for piston....655
Impulse air pump 562
Impulses and waves of electric current....266-256-265
" or power strokes, 6 cylinder....123-125
" " " " 12 cylinder 134
" " " " how overlap 101-126
Impulse starter, K. W. 832
"In" and "out" of clutch....38-39
Inches converted into degrees....114-314-541
" decimal parts of 541
" symbol of 541-98
Inch, hundredths part of 115
Inch, thousandths part of....541-691
Inches to centimeters 540-544
Inches to gallons, in Ford tank....824
Inches to millimeters ....539 to 541
Increasing power of engine 809-585-586-627
Indian motorcycle (Insert No. 3 & 2)....844-811
Indications of ammeter 417-410-416-414
" " carbon 625
" " open and short circuits....415-413
" " noisy rear axle 932
" " weak batteries 422
Indicator for electric system....410
" " oil, Hudson 200
" or trammel for valve timing....114-102
Induced current, explanation of 219-221
" " in primary coil 223
Inductor type armatures 265-264-256-274
" " magneto 264-265-288
" " " setting of 586
" " " timing of 264
Inertia gear drive (Bendix) 326-331
Inflation pressure of tires....553-554
Information relative to any car, where to obtain...533
Inherent control of current 339-345-346-363
Inland piston rings 655
Inlet and exhaust valves, size of 91-609
Inlet and exhaust manifolds 83-164-159-157
" manifold too large or small....164
" valves 65-89
" " opening and closing.... 96
" " spring weak 635
Inner shoes for tires (also reliners)....568
" tube and valve 549
" " average life of 569
" " blow outs 572
" " cementing a patch 569
" " cut and torn 572
" " how to fold 568
" " pointers 569
" " proper amount chalk to use....591
" " removing of 558-569
" " repairs ....566 to 570-572-574-575
" " splicing of 572
" " steam vulcanizing 572-570
" " using oversize and undersize....569-590
" " valves 558-549
" " stem repair 572
" " vulcanizing of ....570 to 574
" " why gray or red....569
" " using soapstone....569
Insignia of airplanes 899
Inspection of a car, engine and parts....510-595
" hole on engine for timing....120
" pits 603-604
" sheet for repairman 740
Instrument lamp 438
Insulation, meaning of 207
Insurance 521
Intensifying the current....214-215-219-260
Intermediate or 2nd speed....51-488
Intermittent motion of valve 87
Internal battery short circuits....456-418-422-457
Internal combustion engines 53-755
" gear drive axle....676
" expanding brake 30-686
" short circuits in battery....418
Interrupter and distributor, explanation of.225-242-259
" adjustments 264-297-298-304
" advancing and retarding of....[illegible]
" cams 309-298-252
" construction 244-298
" for magneto and coil 260
" "magneto" type 243
" of Remy magneto 298
" on magneto 272-273-298
" or contact breaker....225-259-242-248
" point gap 542-264-315
Interruption of current, with vibrator 228
INT, meaning of ....(see dictionary)
Intoxicated persons driving 508
Irregular firing 579-300
Irreversible steering gear....25-691
Iron and steels 721
" soldering 711-614-586
" wire resistance coil 339
INSERTS: No. 1, page 16a; No. 2, page 140a; No. 3, page 288a; No. 4, page 864a.

J

Jacks 741-592
Jack for rear axle 741
Jack for straightening bent parts....789
Jackshafts, purpose and position of....18-20
Jacox steering device 692
Jar for battery 439-444
" " " its value after broken....471-457
Jeffery spark and throttle control 496
Jeffery Quad, 4 wheel drive truck....743
Jeweler's file, for dressing platinum points....234-309
Jew speeder wrench 824
Jig for drilling holes for cotter pins....789
Johnson carburetor 184
Johns-Manville speedometer 512
Jordan rear axle adjustment 674
Judging a second-hand car 528
Jump spark coil ....218 to 220
" " " tests and troubles....238
" " " without vibrator 245
Junction or coupling box for wiring....426 to 428

K

Keeper, advisability of using on magnets....308
Kerosene and gasoline, proportions of 585
" carburetors 754-160-827-828-881
" " where used 166
" difficulties 881
" for cleaning crank case....201-595-621
" " " engine 491-201-621-594-740
" " fuel, clean crank case often....881
" " cooling, not advised 585
" freezing, boiling point and specific gravity.585
" how used for steam car....763-765
" to loosen rings 656
" smoke indications 881
" tub, for cleaning parts....741
" vaporizer 826
Key to motor car parts 1
Keys and keyway cutting 708
Kick switch 277
Kilogramme, meaning of 541
Kilometre, meaning of 540-541
Kind of lubricating oil to use....200-201
King car carburetor 184
" electric system 331-360
" ignition timing of 360
" oiling system 198-200
" spark and throttle control....496
" specifications 545
Kingston carburetor 160-798-153
" kerosene carburetor 754
Kissel-Kar specifications 545
Klaxon horn and tests 514-515-418
Knock, cause due to bent connecting rod....[illegible]
" cause of....635 to 639-580-591
" caused by pre-ignition 689
" locating with sonoscope....838
" piston slap, cause of 637
" places to look for 638
Knocks, testing for 639
Knight engine 139
" " history of 537
Knots, how to tie 784
Krebs carburetor principle 144
K. W. high tension magneto 288-832-928
" impulse starter 832-929
" inductor type armature 256
" low tension magneto 264
" magneto connections 296
" " explanation of 265
" master vibrator coil and magneto....264
" tractor engine ignition 832

L

Ladle for melting purposes 696
Lag of explosion (foot note).......... 68
'' '' electric current 243
'' '' valve, meaning of 98
'' '' valve timing 101
Laminated armature core 258-268
'' shims for bearings 641
Lamp, amperes of 481-488-467
'' base and sockets, cause of short circuits....413
'' bases 432
'' burns bright but engine will not crank.....457
'' '' but fails to illuminate road..........420
'' '' dim 456
'' '' '' when starter is working..........420
'' '' out often 420
'' candle power, amperage & voltage..482-484-467
'' dim, due to armature trouble..........411
'' dimming of 437-828-824
'' does not light 419
'' electric 482
'' '' where used on a car..........483
'' fails to light 415
'' filaments 432
'' flickers 420-421
'' (headlight) how to focus 488-485
'' for shop 735
'' '' testing circuits 744-418-403-399
'' '' working around car 604
'' gas and nitrogen 432
'' goes out for instant only..........420
'' grows dim when engine is speeded up......420
'' if one burns dim 420
'' lens 429-483-435
'' nitrogen filled 435-432
'' reflector, polishing of 742
'' resistance for charging batteries...465-460-461
'' size and shape, how designated..........434
'' sizes of Ford lighting system..........484
'' size to use 432-484
'' too bright 420
'' troubles and testing.......419-710-416-418-403
'' voltages ....431-482-434-543 to 546
'' watts and candle-power 467-431
Landaulet, definition of.......... 15
Lap of power strokes in multi-cylinder engines.126-184
Lap, zero, minus and plus..........101
Lapping compound 649-650
'' piston to cylinder 650
'' ring to cylinder 657-650
'' '' '' fit groove of piston..........658
'' tools 650-649-657-658
Lathe chuck and tools 615-711
'' how to run 743
Lathes, prices and sizes of 617
'' drill presses, etc., how to belt and drive...618
Lavine steering device 692
Laws, Canadian auto 524
'' Canal Zone 524
'' different states 522-523
'' on lights too bright..........437
Lay out of a machine shop 617-618
Leading carburetors 171
'' cars, standard adjustments..........542
Lead burning 439
'' '' of battery connectors 471-472
Lead of valve 101
'' oxide 445-447
'' sulphate in battery 447
Lead wire, meaning of 207
Leak of compression, causes of (see also compression)628
Leak-proof rings 655
Leaks, air and gasoline 162
'' cylinder 193-718
'' gasoline 162-193-712
'' stopping with sal-ammoniac..........718
Leaking oil from bolt holes 584
Leaky carburetor needle valve 585
'' inner tube, testing of 568-567
'' piston rings ....201 to 203-655
'' radiator 191-715
'' top, how to repair..........847
Lean mixture 169-170-579
Learning to operate an automobile..........485
Leather for clutch, treatment of..........660-661-664
'' tread tires 551-559
Leece-Neville electric system 878
Lengths of spark plugs 287-288
Lens, non-glare 429-435
Level of float 147
Lever movements and gear changing..493-490-488-486-51
'' '' of leading cars 542
Levers, spark, throttle, and gear shift..........485
Liability insurance 521
Liberty engine 988
License 522-523
Lifting bodies 748
'' engine from frame 605
'' power of magnets 584-808-806
'' transmission from car 787
Lift of valve 95-11
''Lift the dot'' curtain fastener 84
Light for working around car..........60
Lighting a car 48
'' '' garage 599-60
'' battery 44
'' car, battery alone 43
'' '' '' and dynamo 48
'' circuits 48
'' circuit, testing of 408-899-41
'' circuits, material for 48
'' '' examples of 426-429-430-48
'' (electric) methods 48
'' (gas) methods 486-48
'' '' by elecric spark (gas, gasoline)..486-58
'' oil lamps 48
'' plant (Delco) 82
'' switch 848-426-427-42
'' '' diagram of 42
'' wire 425-427-42
'' with magneto 482-264-26
'' troubles, digest of 41
Lights ....432 to 434-487-46
'' dim 419-45
'' dimming of 429-437-588-79
'' how many required 17-48
'' regulation of in cities 50
Limousine, definition and derivation..........15-58
Lines of force about poles of magnet..........26
Litre, what equal to 54
L-head cylinders 8
'' cylinder vs. ''T'' and ''I'' head 58
Lincoln Highway, map of 52
''Lined'' bearings 64
Liners 74-64
Lining for brakes 688-691-689-69
'' up pistons and connecting rods.646-649-659-78
'' '' wheels 68
Line shafts, for shop 61
Lines of force (electric) 221-267-26
Liquid rubber paint 50
'' type speedometer 51
Litharge for battery plates 445-44
Live axles, disadvantages of......81-50-21-13-673-67
Loading up of engine..........169-578-589-175-58
Locating knocks 685-687-688-78
Location of spark plugs 235-28
'' '' transmission 4
'' '' valves 9
Locking a car 584-589-73
Locomobile chassis 4
'' dashboard 498-50
'' firing order 862-54
'' gear shift 50
'' ignition timing 86
'' spark and throttle control..........50
'' specifications of 54
'' steering column 49
'' valve timing 10
'' wiring diagram 86
Long body spark plug 28
'' stroke, meaning of 8
'' '' vs. short stroke engines 58
Loop connections, bow to make..........74
Looseness in chain how detected (see chains)......72
Loping of engine 16
Loss of power 62
Low gear, speed ratio 12-583-2
'' grade gasoline vs. high grade...158-161-585-15
'' tension coil 214-21
'' '' '' advantages and disadvantages...25
'' '' '' and battery system..........26
'' '' '' ignition 206-215-21
'' '' ignition ''make and break''..214 to 21
'' '' '' system 213-26
'' '' '' timing 31
'' '' magneto and high tension coil..259-26
'' '' '' '' make and break system of iguition 26
'' '' '' construction 25
'' '' '' inductor type (K.W.&Remy)26
'' '' '' relation to high tension....26
'' '' '' with coil and battery to start on 26
'' '' wires 24
Low to high gear 51-486-48
Lubricating a speed car 760-76
'' car 203-59
'' differential 205-669-62
'' electric horn 51
'' engine 201-59
'' oil, relation to carbon......202-658-62
'' oil tanks 601-60
'' springs 622-74
'' with graphite 20
Lubrication ''ball and spring'' adjustment.198-200-85
Lubrication cause of smoke 202-203-658-62
'' circulating system 20
'' cold test 20
'' force feed 199-85
'' general for all parts of car......208-20

Lubrication gravity 196
" mechanical pump 195
" methods on leading cars 543
" of a new car 491
" " Cadillac 129
" " Delco electric system 397
" " disk clutch 208
" " engine (also see oil and oiling)...201
" " Hudson 198-204-694
" " King car 198-200
" " parts on a modern car..............204
" " rear axle 204-205
" " starting motor 331
" " Studebaker 204
" " transmission 203-204-669
" " truck engine 834
" piston pumping oil 202-653
" pointers 203-204
" pressure 199
" troubles 201
" truck springs and axle..............749
" using exhaust for pressure..........195
" systems explained 196-199
Lubricator stops working 581-741
Lug for battery 439
Lugs for tires 549
Lycoming engine 71
Lynite pistons 588-651-75-645

M

McFarlan rear axle adj. and specifications....673-545
Machine bolt 701
" shop equipment 617-618
Machinist's hand tap 704
" vise 615
Mag-dynamo, motorcycle 811
Magnetic field, explanation of 221-266-267
" gasoline tank gauge 514
" gear shift 482
" latch 483
" transmission 480-481
" type speedometer 513
" type switch 329
" valve lifter 710
" vibrator 220-225
Magnetism, explanation of 221-267
Magneto, action or principle of 266
" advance and retard of spark.....305-267-277
" airplane use 918-922-293-927
" a mechanical generator 256
" and battery and coil ignition timing.312 to 318
" average advance of 309
" armatures 256-258-274-304
" " high tension..271-268-288-290-304
" " relation to distributor..294-295-301
" " relation to interrupter.........309
" " speed 294
" " testing of 302-304
" " winding connection of 258
" Berling 312-926-927-304
" "Bosch" 268-280-283-284-288
" " DU4 268
" " double system 276-277
" " setting of 310
" " two spark and two point.283-284-277
" cam and interrupter relation 313
" " relative speed 259-267-281
" care of 297-301
" circuit breaker 272-304
" clockwise and anti-clockwise....306-296-318
" coil damaged 300-304
" connections for firing order..............296
" construction (low tension)................257
" coupling 302
" disassembly 304
" distributor and interrupter explained.....259
" " connections 295
" " speed relations of...........306
" "Dixie" (see also Insert)..........290-293
" Dixie motorcycle timing 292
" driving end of 313
" drive methods 294-295
" eight cylinder 293
" "Eisemann" 285-288-289
" fitting to engine 302
" fixed spark 307
" " speed 295
" (Ford type) 265-805
" for lighting 432-264-265
" for tractor (K. W.).......................832
" four or six cylinder engines 306
" gears, removing 302
" condenser (alcohol) 730
" " (electric) . . .269-273-228-229-245
" how connected to engine....................301
" high tension 269
" how to stop generating current.259-275-276-299
" how used alone 287
" ignition, advantage and disadvantage....255
" igniton, meaning of term......341-376-244
" interrupter adjustments........297-298-304
Magneto interrupter gap 315-304
" " (Remy) 298
" ("K. W.") 265-288-296-832-928
" laminated armature, core of...............258
" lines of force 267
" low tension and high tension coil.259-287-258
" " " coil and battery to start on,
261-256-267-214
" " " "inductor" type 265-313
" " " 214
" magnets disassembled 303-304
" " finding N. or S. pole.........303
" " how to test 303-304-864J-305
" " re-magnetizing of 300 to 304-307-319
" manufacturers, addresses of 288
" maximum position 267
" (Mea) 288
" motorcycle (Insert No. 3)..................811
" oiling of 299
" or dynamo voltage, what depends upon..212
" parts, speed relation of.......295-308-306
" peep hole 297
" pivoting type 288-289
" points pitted 298-304-234
" principle of 256-257
" ratio of gearing 294
" (Remy) 264-288
" repairing . . ..288 to 304
" safety spark gap 299-278
" separating distributor cables..............297
" setting armature 310-311-267-309-313
" " by degrees 311
" " use of coupling 302
" " Splitdorf, Remy, Eisemann.....313
" silent chain drive 294
" simple form of 267
" Simms 312
" single, dual and double systems.......276
" "spark gap" 291
" spark control 305
" speed 295-294
" " relations of parts 306
" (Splitdorf) 288-313-926
" Splitdorf-Dixie 290-298-922
" " " setting of 292
" switch 275-259
" synchronizing the points and distributor.301
" testing of 302-303-304
" " magnets 301-303-864J
" timing ....310 to 313-315 to 318-267
" " checking of 316
" " inductor type 264
" " (Locomobile) 362
" troubles 299-300-301
" two-spark ignition (Bosch)..................283
" twelve cylinder 293
"Magneto type" interrupter on coil system.......244
Magneto will light lamps......................265
" vibrating duplex system.....................288
" what geared to and mounting.......294-302
" winding 268-271
" " testing of 301-304
" wiring of 297
" with automatic advance 287-289
" wire, size to use 240
Magnets of magneto 256-258-272-300-303-319
" and "field of force" 266-267
" and pole pieces 271
" electro field 256-257
" for producing the magnetic field..323-325-328
" how prevented losing magnetism......300-303
" how to find polarity.................303-305
" lifting power 584-303-306-301
" of magneto, how to test........303-304-864J
" made of steel 303
" of magneto, how to remagnetize 303-819-864J
" permanent field 256
" principle of 400-267
Main air supply of carburetor 147
" bearings of crankshaft 641
Make and break ignition explained..............260
" " " " timing 315
Make and break ignition on multiple cylinder
engine 208
" " " " system ....214 to 217
" of engine used on leading cars.......543 to 546
Making wire connections 240-241
Malleable cast iron 731
Manifold construction 88-164
Manual control of spark.....246-249-377-157-159-164
Manifold, "hot pin" 160
Manufacturers, addresses of.....(see index, Address)
Map of Lincoln Highway.........................520
Marine engines 755
Marking fly-wheel 105-107-98
" piston rings 659
Marks on fly-wheel, for timing.....104-102-105 to 107
Marmon gear shift 499
" rear axle 82
" spark and throttle control...........496-499

Marmon specifications 545
" "84," valve timing of 113
" valves, overhead 90
" wiring diagram 361
Marvel carburetor 179
" valve grinder 592
Master carburetor 180-168
" or Hunting-link of silent chain....728
" vibrator coil 230-232
" " " advantages and disadvantages.255
" " " connections 264
" " " Delco relay system similar....374
Match, substitute for 586
Maximum gravity 489
" position of magneto armature....267
Maxwell, adjustment of transmission....670
" disconnecting battery 423
" firing order 367-542
" ignition 367
" racer valve timing 108
" rear axle adjustments 675-676
" re-designing old car....762
" spark and throttle control 496
" specifications 545
" steering device 693
" valve grinding 633
" " tappet adjustment 738
" wiring diagrams 365-366
Maybach carburetor principle 144
Mayer carburetor 180
Mazda lamps 482
Mea magneto 288-289
Meaning of degrees 93-541
" " "GRND" 213
" " "INT" ....(see dictionary)
" " inches, seconds, feet, minutes....541
" " resistance 209
" " valve lap, lag, and lead....101
" " valve timing marks. on fly wheels....104
Measuring current, method of.416-410-398-399-414-415
" instruments, use of 414-697
Measurements of rims for tires 554
Mechanical generator of electricity....210 to 212
" " regulation methods 337
" governor control of electric system.347-351
" lag 243
" vibrator 220-223-225
Mechanically operated needle valve....174
" " valves 91
Melting points of metals 539
Mercury arc rectifier 463-465
" cooled exhaust valve 824
" regulator (Delco) 380-347
Meshing gears....111 to 113-109-89-386
" sprockets (silent chain)....113
Metal polish 508
" melting point of 539
" saw, how to use....713-710-739-617
Meter, (see am., voltmeter) 414-377-398-410-415-424-864K
Metering pin and dash pot....151-149-586
Metres to yards 539
Metre, designation or symbol of....541
Metric scale rule 540
Metric spark plug 238
" sizes of tires to inches....554
" tables 541
Meshing timing gears on "T" head engines....106
Mica cutting down on commutator....404-409-743
" for spark plugs 238
" peep-hole, on distributor 297-310
Michigan low tension magneto, coil and battery...262
Micrometer 698
" caliper 698
" Vernier scale 698
Miles and kilometres 540
" of roads, different states 584
Millimetres, dimension of 539-540-312
Millimetres to decimals 540-541
" " inches 540-539-541-554
Milli-volt reading explanation 414-453
Miniature base for electric lamp....433
Minus lap, meaning of 101
" sign (—) meaning of....213
Minutes, designation of 541-93
" seconds and degrees 93-541
Mirror for attachment to dash....514
Miscellaneous devices for Fords....824
" shop devices 730
" tables 539
Misfiring, causes of—see digest of troubles and missing....735
Missing at high and low speeds....299
" of explosions 170-233-298-300-241-236-237-808-804-806-735
" " " testing of (see index testing).249
" testing which cylinder....237-236
" on two cylinder opposed engine....587
" with spark retarded or advanced 298
Mitchell adjustment of transmission 671
" clutch 662
" dash board 498
Mitchell ignition timing 258
Mitchell-Lewis wiring diagram 367
" spark and throttle control....496-498
" specifications 545
" steering device 690
" valve timing of 106
Mitre cut, piston rings....609
Mixing electrolyte 448
" tube and mixing chamber 143-147
" valve for two cycle engine....756-141
Mixture, at high and low speeds....168-579-298
" how to determine and test....168-169-585
" not correct 142-578-579-169-170
" of carburetion, heating of....159-157
" proper 61-169
" rich and lean 169-170-579
" which heats engine 586
Modern battery and coil ignition system...242-287-245
Money making additions for shop....610-601
Monarch governor 842
Mono-block cylinders (see dictionary)....659
Monosoupape 910
Monroe, specifications of 545
Moon spark and throttle control....496
" specifications 545
Morse chains and vibration dampener....728
Motometer, (Boyce) 188-511
Motor and engine, difference 58
" " generator combined 386
" boat horns 515
" boat, Ford engine 825
" bob 765
" clutch, (Delco) 387
Motorcycle carburetor 845
" engines (Insert No. 3)....755-843
" engine fly wheels.... 74
" electric system 848-811
" magneto timing 292
" transmission 845
Motor multi-polar 828
Motor, (electric) parts of 328-328-325
Motor-generator "double decker" 352
" " for battery charging....462-864K
" " principle (Delco) ...379-380-387-386
" " system, parts of....347
" how converted into a generator....352-347
" principle of 400
" tests 407-416-424-410
" type electric horn 514-515
" wheel 755
" winding, (Delco) 381
"Motoring" generator (Delco) 399-386
Mud chains for tires 560
" guards bent, how to straighten....745-781
" how to pull car out of....784-517
Muffler and exhaust pipe....88-12
" cut-outs 84-608-732
" overheats 580
" racing car effect 761
Multiple disk clutch 41-40-663-666-667-779
" " " adjustments 663
" jet carburetor 148-179-180
" switch connection 427
Multi-polar motor 328
Mushroom valve lifter 94

N

N. A. C. C.—meaning of 534
Nash, hot air carburetion 159
" truck 748
N and S poles of magnets, how distinguished..303-300
National dashboard 498
" spark and throttle control....496
Neats-foot oil, for clutch 660-682
Needle valve, automatically operated....172-151
" " for carburetor 148-166
Negative and positive pole connections....229-445
" " " " how determined....212-452-453-356
" " " terminals 209-445
" plates 445
" " give less trouble than positive....469
Neutral position of gear....38-48-46-51-486
New engine "running in" 203-489
Nickel and brass polish 508
" steel 721
Nitrogen gas filled lamp 482
Noises about car, to stop 717
" in drive gears, how to eliminate...673-674-932
" in engine, see knocks 639
" in rear axle, how to detect....739-932
" in rear axle, how to elimnate...672 to 678-932
" " transmission 580
Noisy valves 96-634
Non-automatic spark (Delco electric system)....394
" -circulating lubrication systems....196
" -freezing solution for gas generators....193-438
" " " " radiator 193
" -glare lens 429-433
" -skid chains 550-559-560
" " tires 550
" -stallable engine 35

Non-vibrator coil 235-245
North-East electric system on Dodge......369-370-733
" " generator chain, adjusting of...411-369-733
Nozzle sizes, carburetion 178
Number illuminator lamp 483
Numbers on batteries, meaning of..........443
Nuts (tight and stripped thread) remedies for....709
Nuts, assorted 607
" bolts and screws 701
" on cylinder heads, to tighten..........717
" to prevent coming loose 710

O

Oakland ignition timing 390
" re-designing old car 762
" spark and throttle control 496
" specifications of 545
" unit power plant 44
Odometer ....511 to 513-17
Office of a garage, plan of 596-599
" work, pointers on 599
"Off," "on," indicator readings, meaning of..417-410
Off-set cylinders 81-82-532
Ohm, meaning of 207
Ohms resistance, when charging batteries.....464-463
Oil circulation stopped, cause of.........200-733-709
" cooling method 915-201
" cups, sizes of 608
" depth of, in crank case..........196
" drips 208-669-581
" emptying from barrel 603-730
" filter 602-603
" for drilling 707
" for timer 247-589
" gauge 199-200
" grooves in bearings 640-644-203
" " " pistons 652-653-202
" gun 592
" indicator 200
" kind to use 200-201
" " " " for thread cutting 705
" lamps converted into electric..........430
" leakage from axles 678
" " " bolt holes 584
" " " engine 203-669-581
" " " valve guides 737
" level in gearset and engine (Dodge)......670-733
" lighting 438
" not enough, cause and remedy..........202
" of vitriol 489
" on clutch leather 580
" pressure gauge does not work........199-581-733
" " regulation 199-200-694
" " various cars 542
" pump, adjustment of 199-694
" " and oil pressure gauge..........199-810
" " " pipes, cleaning of 200
" " fitting to racer 760-761
" " priming of 200
" " relief valve 859
" regulation, spring and ball and eccentric.200-694-741
" relation to spark plugs..........233
" settling tank 603
" soaked spark plugs 202
" storage system 736
" " tanks 602-608
" testing of 201
" too much, cause and remedy..........202
" trucks for garage 739
" using over again 201
" waste, due to piston rings..........658
Oiling and greasing a car 622-203-204
Oiling and greasing Hudson and Studebaker, examples of 204
" and greasing, price charged..........595
" of magneto 299
" system of King, Hudson 198-200-694
Oiling systems; splash, semi-splash 197
Old cars, re-designing and speeding up.....760 to 762
" gasoline 163
Oldham coupling for magneto shaft 302
Oldsmobile dashboard 498
" spark and throttle control..........496
" specifications of 545
" wiring diagrams 393-394
Old tires, price of 588
"One-piece" clincher rim 552
One piece spark plug 238
One way streets, meaning of 503
Open and close circuit principle of ignition..........248
" circuits 415-418
" circuit, ignition system..........242
" " coil test 402
" " tests 416-418
" end wrenches 611
" cure, meaning of 564
Opening and closing of exhaust and inlet valves.... 96
Opening a headlamp 437
Operating a car 485-492
" " truck 749
Operation of Packard 850
Operation of transmission 50
Opposed type engine 70
Order of firing of cylinders 118
Ordinances of St. Louis 501
Orphan cars, or those no longer manufactured.....547
Overhauling a car 594-620
" " " prices usually charged..........595
" brakes 688-689
" and adjusting clutches.........661 to 668
" gearsets or transmissions......669 to 671
Overhead valves, advantage of....85-91-94-686-532-627
" valve clearance 94-109-636
" " engine 186-636
" " grinding 630-636-90
Overheating 189-201-579
" due to spark control..........319
" of battery 457
" " exhaust pipe and muffler..........580
Overland, adjustment of transmission 670
" carburetor 188
" clutch adjustment 666
" clutch spring compressor 647
" dash control units 497
" disconnecting battery 423
" electric starter and generator........358-324
" engine, fitting main and connecting rod bearings ....647 to 649
" firing order 359-542
" gear changes 49-490
" piston lapping tool 649
" re-designing old car 762
" removing piston 646
" socket wrenches 592
" spark and throttle control 496
" specifications of 545
" sprocket chain tightener 648
" steering device 693
" wiring diagram 358
Overloading of carburetor 175-586
Over-oiling, prevention of 202-652
Over-running clutch 341-386-398-351-690
Overshoes for tires 569
Oversize inner tubes 569
" pistons 609-792
" " where to obtain 823
" stud, how to fit 709
" tires 553-554
" valves 630-609
Overslung and underslung, meaning of.......... 11
Outer shoes for tires 568
Outfit for welding 727
" of tools for the auto mechanician..592-594-795
Outfits for camping 516
Out of gasoline, what to do..........585
Owen magnetic, specifications of 545
" " transmission 480-481
Owners license 522
Oxide of lead 445-447
Oxy-acetylene cutting 724
" " welding ....718 to 727
Oxygen decarbonizer 624-625
Oxy-generator of steam (superheated)..........735
Oxy-hydrogen for welding 725

P

Packard adjustments 850
" battery and generator disconnecting of...423
" carburetion 855
" dash board and control units..........498
" electric system 857
" engines 851-853
" firing order 135-542
" former method of ignition 263
" gasoline system 854
" gear shift 498
" ignition 856-850
" " timing 850
Packard, radiator test 715
" spark and throttle control..........496
" specifications of 546-825
" supplement 850
" vibration dampener 850
" water type governor (old model)........154
Packing for carburetor flange..........159-164
" of water pump 191
Paige dashboard 498
" spark and throttle control..........496
" specifications 546
Paint for battery box 473
Paint for tire 509-571
Paint, heat proof 509-588
" on aluminum, how to remove..........401
Painting battery box 473
" gear changes 49-488-490
" car 509
" cylinders, engine and manifolds......509-588
" fenders after repairing 745-781
" garage walls 736
" radiator 194-509-736-588
" tires 568
Pan cakes, how to make when touring..........[illegible]
Pantasote, meaning of ....[illegible]
Paper gaskets 717
Parabolic reflectors for headlights..........431-[illegible]

Parallel connections 208-466
Parking rules 508
Parts, for cars no longer manufactured..........547
  '' of a battery and coil system of ignition.....245
  '' '' a battery (modern) 446
  '' '' a carburetor 145
  '' '' an electric generator 335
  '' '' an electric starting motor..............325
  '' '' a spark plug 218-238
  '' '' clutches (see clutches).........37-38-40-662
  '' '' engine 72
  '' '' steam engine 765
  '' to lubricate on a modern car 204
Peak of waves of electric current.........256-265-266
Pedal and adjustments for clutch..........665-662
  '' systems 485
Pedestrians, rules governing street crossings.......501
Peep-hole on distributor of Bosch magneto........310
Peerless, specifications of 546
Per cent grade, how to find..............539-588
Periodical attention to a car....................510
Periods of valve opening and closing..............100
Permanent and electro fields (see electric)....335-332
  '' field magnets (see magnets)257-212-323-325
Peroxide of lead 445-447
Philbrin ignition timer 252
Picric acid in gasoline for racing..............809
Pierce-Arrow dashboard 498-500
  '' '' ''dual'' valve engine..............927
  '' '' electric system 349
  '' '' ignition timing 496
  '' '' gear shift 490
  '' '' spark and throttle control.......500,496
  '' '' specifications 546
Pierce governor 840
Pig-tail connection on brushes 404
Pillar lamp 483
Pilot light for welding 626
  '' '' '' steam car 764-765
Pinch bar 787
Pinion adjustment 673-674
Pinned piston ring 653-655
Pipe capacity 539
  '' dies, for small pipe work 608
  '' fittings 608
  '' taps 704-608
  '' threads 702-704-703
Piston ....74 to 76-202-645-609-652-659
  '' aluminum 75-645-651-792-609-813
  '' and connecting rod, lining up of.659-646-649-733
  '' '' piston ring questions answered........651
  '' cause of excess of oil 653-202
  '' cast iron and aluminum 645
  '' clearance 651-649-792-588-75-645
  '' '' greater at top....................651
  '' '' too slack 653
  '' displacement 538
  '' fit too close to cylinder wall..............651
  '' finding position of 320
  '' for high speed work 75-792-813
  '' lapping 649-650
  '' lining up of 646-649-659-733
  '' loose and test for 688-651
  '' ''Lynite'' or aluminum alloy...75-645-651-588
  '' oil grooves in 202-653
  '' oil pump for Ford 810
  '' or wrist pin 74-643
  '' oversize 609-792-653
  '' '' where to obtain 823
  '' pin or wrist pin ....73 to 75-85-644-645
  '' pin, removal of 650
  '' pumping oil 202-653-652
  '' relation to smoke and excess of oil........652
  '' replacing into cylinder 659
  '' replacing V-type 741
  '' rings 75-654-655-651-791-792
  '' ring clearance at gap 649-655
  '' '' concentric and eccentric..........651-654
  '' '' filing 658
  '' '' lapping of 657-649-650
  '' '' '' to fit groove 658
  '' '' leak, test of 656
  '' '' leaks, cause and effect..............655
  '' '' mitre and step-cut..............655-609
  '' '' removal of 657
  '' '' and excess oil relation..........658-200
  '' '' cause of loss of compression..........628
  '' '' cut or scratched 656
  '' '' fit bottom one first 658
  '' '' fit best one at top....................659
  '' '' for fitting ends 657-735
  '' '' fitting to cylinder 657
  '' '' fitting to piston 658-659
  '' '' if dull and dirty 655
  '' '' if in good condition smooth and shiny..655
  '' '' leak 201
  '' '' leak, result, oil soaked spark plugs..202-208
  '' '' lost tension 656
  '' '' marking of 657-659
  '' '' patented type 655
  '' '' pinned 653
  '' '' poening of 657
Piston ring size on leading cars........609-543 to 546
  '' '' sticks in groove 628-656
  '' '' to loosen with kerosene..............656
  '' '' too tight, cause; lack of lubrication....658
  '' '' troubles and remedies 656
  '' seized 639
  '' slap 687
  '' speed 534
  '' strokes of 57-116
  '' travel in inches and degrees..............314
Pit, for working under car..............603-604-739
Pitch gauge 700
  '' of screw threads 698-700-702
  '' '' thread, how to measure..............702
Pitot carburetor principle..............800-177-149
Pitted platinum points on magneto........298-304-234
  '' valves 92-680
Pitting of vibrator points 234-235-229-808
Pittsfield ignition timer 252
Pivoting type magneto 288-289
Plain bearings for engine..........72-640 to 644-208
Plain tube carburetor (Pitot)........149-176-177-800
Planetary gears (see Ford Supplement)........46-775
Plante type battery plate 440-445
Plate type clutch..............41 to 48-50-668-669
Plates, battery ....445-440 to 442-444
  '' of batteries, straightening..............468
Platinum 234-259-248-804
Platinum points, dressing of 234-809-804
Pliers, combination type 614
Plug (drain) where situated 201
Plug (fire) parking near 503
Plugs, spark (see spark plugs)..............219-238
Plunger or tappet, valve type..............92-94-649
  '' type oil pump 199
Plus lap, meaning of 101
Plus sign (+), meaning of 218-445
Pneumatic tires 549-565
Pocketed valve 712-631
Poening piston rings 657
Pointer on office work 599
Pointers for auto salesman ....529 to 533
  '' '' repairman 593-594
  '' on changing gears 488-493
  '' on driving 505
  '' '' general lubrication 203-204
  '' '' inner tube repairs 569
  '' '' operating a car....................492-488
  '' '' selecting a pleasure, commercial car
    and second hand car 527-528
  '' '' tire repairs 571
  '' '' vulcanizing inner tubes......573-572-574
  '' '' welding 726
Points, (spark plug) 238-234-804
  '' (vibrator) sticking 235-808
Polarity, meaning of 439-452
  '' of battery, how determined.........452-212
  '' or pole changing switch 248
Pole finding, with rectifiers not necessary.........468
  '' pieces and magnets 271
  '' '' of magneto 258-267-452
  '' '' '' starter motor 328-325-328
Poles of a storage battery, how determined........212
Polish for bodies 507-508
  '' '' glass 508
  '' '' nickel and brass 508
Poppet type valve 91
  '' valves, why so called 587
Popping or back firing in carburetor..........170-169
Porcelain for spark plugs 218-238
Portable, blacksmith's forge 615
  '' lamp for working around car..........604
  '' work bench 605
Port opening of valve on engine 88
Position of piston, how to find..........105-114-320
  '' '' spark plug on engine 219
Positive and negative pole connections 229
  '' '' '' '' using volt meter to find.458
  '' '' '' terminals 209
  '' '' '' '' grounding of...218-421
  '' '' '' '' how determined..212-452
  '' plates 445
  '' '' buckle oftener than negative.......469
Potash solution for cleaning metal parts..........401
Potatoes, how to cook, when touring 519
Potential or voltage regulation 345-349
Power air pumps ....562 to 564
  '' cause of loss 626
  '' hack saws 617
  '' impulses, six cylinder 128
  '' '' twelve cylinder 135
  '' of engine, how increased.......809-585-586-627
  '' plant, purpose of parts 10-11
  '' stroke 57-116
  '' strokes, overlap of 12 cylinder engine......134
  '' to run machinery 617
  '' transmission, different methods of 14
Precautions, cold weather.....193-451-585-586-589-804
Pre-heating and re-heating 719-72
  '' '' furnace 720-72

Pre-ignition 639-283-625
Premier gear shift 482
Preparing car for service 487
Pressure gauge for oil 199-200-694
" of air in tires. 553-554
" gasoline system 854
" " oil, regulation of. 199-200-694-741
" " oil, leading cars. 542
Prest-o-lite gas tank 436-438
" " starter 322
" tank, if can use to clean carbon. 626
Prest-O-Vacuum brake .479
Prevention of over-oiling 202
Prices and sizes of hack saws, and other shop equipment 617
" and sizes of lathes. 617
" for storage and repairs in garage 599
" of shop machinery .618
" to charge for battery work 473
" " " " welding 723
" usually charged for miscellaneous repair work 595-794
" usually charged for tire repair work. 574
" usually charged for welding and cutting.728-725
Primary armature winding 274-257
" cable 240
" coil winding 215-221-245
" switch, testing 253
Primer (electric) for carburetor. 157
" for gasoline 156-321-801-823
Priming, air intake 855
Priming 153-156-321-322-801-823
" cups 65-801-823
" engine 153-156-589-801-823
" oil pump 200
" rod for carburetor .160
" starter for engine .322
" with high gravity gasoline 156
Principle of carburetor 142
" " Diesel engine .587
" " electric motor 400
" " generator 332-333-335
" " high tension coil 221
" " magneto 256-257-266
" " oxy-acetylene blow pipe. 724
" " ignition 206
" " tractor drive 752
" " two-cycle engines 756
" " volt-ammeter .898
Process of elimination in trouble hunting. 577
Progressive type transmission 46
Pronunciation of auto words. 582
Prony horse-power brake test 536
Propeller or shaft drive 19
" type, fan 192
Property damage insurance 521
Proportion of air and gasoline 586
Protractor, what used for. 541-107
Prussian blue test for valves and bearings. . . .630-643
Publications, auto 529
Puller for gears 743
" " generator gear 738
" " steering post 736
" " wheels 606-737-742
Pulling car out of mud 734-517
Pullman spark and throttle control 496
"Pull-U-Out" 518-734
Pulleys, how to find proper size. 563-617
Pump for air 562-553-564
" " gasoline 602
" " oil 199-200-810
" hand for lubrication. 197-814-816
" leaks 193-191
" mechanical for lubrication 195
" packing of 191
Pumping oil by piston 202-653
Puncture proof tire 559
Purpose of spark plug 219-238

Q

Quick detachable clincher reversible rim. 552
" " demountable rim. .550 to 552-555-557
Quiet cams 99
Questions and answers 581
" answered on pistons and rings. 651
" " " reboring cylinders 654
" " " steam cars 763-765
" sometimes asked by examining board. . . .524

R

Race, first official road race 581
Racing car lubrication 760-761
" driver's earnings 582
" engines, valve timing of. 108
" records 540-582
"Racy-type" cars, to convert. . . . . .760 to 762
Radial bearings 36
Radiators 187
Radiator, cleaning of .191-789
" cold solder for 715
" cover 188
Radiator, extension tank .190
" frozen, how to tell. 193-579
" height of water in .185
" hose 608
" how to keep oil off hose. 622
" leaky 191
" marking leaks .715-191
" painting of 194-509-736-584
" repairing of 194-714-789
" shutter device 188
" soldering 715-711-614-586-789
" syphon tank 190
" testing for leaks 715
" why should be kept full 590
Radius rods 18-20-21
Railway (overhead) for repair shop 740
Rain and snow, how to prevent on wind shield508-849-732
" spots, how to remove 507-508
" vision, wind shields 732-849-823
Raising a car to work under it 604
Range of spark advance 249-312-319
Rates for charging battery 461-467
Ratio of car and engine speed.12-22-294-537-583-775-781
" " drive, leading cars . . . . .22-543 to 546
" " gearing (Ford) 780-781-815
" " " leading cars 583
" " " magneto 294
" " " Timken rear axle 674
" " transmission gears 669-583
Rays of light, meaning of. 433
Rayfield carburetor 151-175
" " float level 167
Readings of an ammeter 414-417
Reamers 706-616
Reaming a hole 708
" cylinder 616-653-654
" ill effects of 712
" valve stem guide 632-630-634
Rear axle and adjustment. . . .31-50-669-672 to 679-932
" " and differential adjustment, Timken. 673-674-678
" " adjustment of Buick. 676-677
" " " " Cadillac 674
" " " " Chalmers 674-678
" " " " Daniels .673
" " " " Dodge 932
" " " " Dorris 673
" " " " HAL 673
" " " " Hudson .674
" " " " Jordan 674
" " " " Maxwell 575-676
" " " " McFarlan 673
" " " " Reo 679
" " " " Saxon 678
" " " " Westcott 674
" " assembly, Chevrolet 671
" " distinction of (S. A. E.). 669
" " driving gears 35-50
" " full floating 33-669-673-677-932
" " gear ratio 674-543-583
" " housing, handy wrench for. 824
" " hums, how to detect 739-932
" " internal gear drive 678
" " precautions 682
" " removing 33-669-932
" " semi-floating .33-669-674
" " stand 730-709-797-824-605
" " " for Ford 744
" " three-quarter floating 33-669-672-673
" " trucks . . . . .749 to 751
" " two speed 483
" " types used on leading cars. . . .669-543-546-673-674
" " with transmission 47
" " worm drive 32-35-750
Rear wheel puller 737
" wheels (Buick), removal of 677
" " (Cadillac), removal of 677
" " removal of 669-679-932
" " (Studebaker), removal of 677
Reboring cylinders 653-654-792-813-616
Recipes for body polish, leather dressing etc. .508-509
Recharging magneto magnets 303-807-819-864J
" magnets, method of construction. 303
Reciprocating motion of piston (see dictionary). . . . 55
Record, dirt track racing 582-540
Rectifier bulb 465
" for charging batteries. .463-465-464-439-864L
" home-made 466
" mercury arc 465
" (Westinghouse) 466
Re-designing old cars . . . . .760 to 762
Reduction gearing, electric starter motor. 328
Refacing and reseating valves. . . . . .680 to 683-92
Reflector of lamp, polishing and plating of. 742
Reflectors, adjusting of 432-435
" how to clean 435
" parabolic 431-433
Refrigeration of carburetor 158-754-585
Regal spark and throttle control. 496

Regal specifications 546
Regrinding cylinders 658-792-654
"Reg."spark plug, meaning of 238
Regular length spark plug 288
Regulating charging current, Delco third brush....390
" oil pressure 199-200-694
" " " leading cars 542
" resistance units, size to use (Delco)...397
" spark 486
Regulation, amperage and voltage.....342-343-345-349
" bucking-series 345
" constant amperage 348-344
" methods of electric generator.343-345-925-337
" of output of generator........334-337-342-343-345-350
" " " Remy system 371-372
" principle of generator 342
" resistance of graphite piles....353
" reverse-series (Delco) 394
" third brush.......345-389-405-385-393-396
" variable resistance.........381-383-384-392
Regulator, constant amperage 342
" mercury type 347-380
" of temperature for carburetor....155
" (Ward-Leonard) 342
Re-heating and pre-heating ....719 to 721-726
Relation between time of spark and combustion....307
" of armature and distributor sped, magneto..308
" " carbon to lubricating oil....628
" " crank-shaft to cam-shaft speed....308
" " distributor to timer....135-131
" " generator and motor 333
" " piston and rings to smoke and excess oil..653
" " speed to time of spark....308
Relative position of piston of 12 cylinder engine...136
" " " pistons to firing impulse (Cadillac) 131
Relay (see also "cut-out") 409
" ignition system 374-375
Relining brakes ....688 to 690
" clutch 660
" tires 567-568
Relief valve of oil pump....859
Re-magnetizing magneto magnets.....301-303-304-300-819-864J
Remedies for battery troubles 422
Remeshing timing gears........87-111 to 113-316-729
Removing a broken stud 709
" a nut 709
" a cam shaft 650-853
" battery 345-423
" bodies 743
" bushings 644-650-824
" carbon 625-735
" clincher tire 558
" clutch, Dodge 932
Removing commutator 804
" crankshaft, Overland method....648-647
" Delco generator clutch 398
" differential 669-675
" " on Maxwell....675-676
" door on electric lamps 435
" front wheel 680-681
" gears from magneto 302
" " tool for 737
" grease spots 507-509
" inner tube 558-569
" magneto magnets 300-303
" piston pin 644
" pistons 646-659
" rear axles 33-669
" " wheels and axle, truck type....750
" " wheels 669-679
" " " Buick 677
" " " Cadillac 677
" " " Studebaker 677
" timing gears 835
" timing gears, Chalmers 318
" tires and rims ....555 to 558
" transmission from car 737
" truck wheels 741
" universal joint 672
" valve caps 634
Remy "double-decker" motor-generator....352
" Electric Co., address of....378
" electric system on Reo 371-372
" electric system (motorcycles) 843
" ignition system 251
" " " (battery and coil) timing.318-252
" " on Studebaker 366
" magneto (inductor type)....264-288-924
" " interrupter 264-298
" " setting of 313
" motorcycle electric system....843
" thermal principle of regulation....350
" "two-spark" magneto 277
" two unit electric system 350
Renault system of cooling 186
Reo clutch adjustments 667
" " spring tool 744
Reo disconnecting battery 423
" electric system 371-372
" firing order 378-542
" engine bearings 643
" ignition timing 373
" rear axle adjustment 679
" specifications of 546
Repainting car 509
" cylinders 509-588
" engine and manifold 509
" radiator 194-584-509-736
Repair business, starting into....593
Repairing and adjusting 620
" a blow-out 575
" axles....669-672 to 679
" bent frames 731
" brakes ....684 to 690
" check sheet for 740
" clutches ....660 to 668-932
" cone clutch ....660 to 665
" cracked cylinder 193-580-713
" cracked water manifold 715
" inner tubes ....566 to 574
" hole in top 847
" magneto 288-301-804
" motor clutch 690
" radiator 194-714-715-789
" silent chains 728
" storage batteries 456-463-471-472
" tires 565-571
" tops 847
" torque arm 690
" transmission ....669 to 671
Repairman, classified 594
Repairman's check sheet 740-600
Repairman's supplies, for battery work....474
Repairmen, pointer for 593-594
" tools for 592
Repair shop 597
" " door (automatic) 730
" " equipment 600
" " fixtures for 599
" " hints and devices 730
" " how to construct ....596 to 598
" " how to lay out ....596 to 598
" " money making additions for.....601-610
" " overhead railway for 740
" " pits 603-604
" " stockroom 601
" " time of year to open....597
" " tools 614
" " sheet records 600
Replacing bearings in transmission....669-670
" cylinders over pistons....659
" pistons in cylinders....659
" valve caps 634
Reseating valves 631-632
Resistance in ohms, when charging batteries...464-463
" units (Delco), size to use....397
Retarding and advancing magneto....294
" " " of spark 227-68-246-319
Resistance (ballast type) 347
Resistance, explanation of 209-439
" for dimming lights 435-824
" in field circuit of generator....334-338-842
" " ignition units 246-250
" required for battery charging....461
" units 347-246-378
" unit (Delco) 246-378-383
" units for charging battery....463-464
Retreading tires 566
Return wire 207
Reversal of flow of current 344
Reverse current cut-out diagram....370
" " type cut-out 346-344
Reversed battery charge 459
Reverse gears, where located 13-48
Reverse-series regulation, Delco....394
Reversing battery terminals 421-417
Reversing car 486-51
Review of coil and ignition systems....255
Revolving cylinder engine....see Gnome
Revolutions per mile of auto wheels....540
Rheostat, water 468
" resistance wire 462
Rhoades ignition timer 252
Ribbon type radiator 860
Rich and lean mixture 169
Right of way, auto or wagon....584
" " " on streets 502-501
" " " on cross streets 584
" " " pedestrians 501
" side of an automobile 134-582
Rim, demounting and mounting of 556
Rim measurements 554
Rim-nut tire-tool 611
Rims for tires....551-550-552-555 to 558
Rims, users of "Firestone" make....555
Rings, piston 75-654-655-651-649-791-792
" cause of loss of compression....628
" expanding pliers for ....

Rings for piston, fitting ends..........657-649
'' of piston, leaky..........655-202-203
Ring gap clearance..........649
Rivet counter-sink..........616
Road clearance of car.......... 17
Roadster, definition of.......... 15
Rocking advance magneto..........288
Rods, connecting..........73-74-78-85-641-645-646
Roller bearings (Timken and others)..........36-687
'' '' for engine..........640
'' chain..........749-18
'' type clutch..........341-386-398-351-690
'' '' '' how to remove..........398
Rope drive, for speedometer..........512
Ross steering device..........692
Rotary engine..........186-188
'' motion, meaning of.......... 55
'' '' of valves.......... 87
'' pump..........187
'' throttle valves..........153
'' valve engine..........136-188
Rotor of a distributor..........245
'' or revolving part of inductor type armature..264
R.p.m. (revolutions per minute)..........863
Rubber for tire construction..........565
'' hose for radiator..........608
'' sheets for battery..........439
'' supplies for stock room..........601
Rules for driving..........504
'' '' passing and turning..........502
'' '' slowing down, stopping, etc..........504
'' machinists..........700
'' milli-metre scale..........540
'' of the road..........501-502
Running boards.......... 4
'' brake..........28-29
''Running in'' a new car and engine......489-203-507
'' '' engine, method of 793-203-507-489-735-643
Rushmore starting motor..........330
'' thermal principle of generator regulation.339
Rusting up a small leak in cylinder..........713
Rutenber engine..........see Insert
Ryerson reinforced bearings..........640

S

S. A. E. and U. S. S. tap and die sets..........612-613
'' '' '' threads..........703-702-288
'' '' '' wrench sets..........611
'' distinction of axles..........669
'' gear shift (standard)..........490
'' horse-power tables..........534
'' meaning of..........534
'' screw and bolt sizes..........612
'' spark plug tap..........705
'' '' '' threads and sizes..........612-238
'' standard for oversize pistons..........653
S. A. E. standard pneumatic tires..........554
'' tap and drill sizes..........703
'' tires, standard sizes of..........554
Safety spark gap..........273-299
Safety spark gap adjusting (magneto)..........291
Sal-ammoniac, stopping leak in cylinder..........713
Salesmanship pointers..........529
Salesroom for public garage..........597
Sandpaper, how to use on commutator brushes.....404
Saw for metal, how to use..........713
'' stand..........605
Sawing metal..........739-710-617-713
Saxon and Studebaker generator and starter tests..406
'' disconnecting battery..........423
'' firing order..........364-542
'' rear axle adjustment..........678
'' re-designing old car..........762
'' spark and throttle control..........496
'' specifications..........546
'' wiring diagram..........364
Scales or rules (machinist's)..........700-540
Schebler carburetor..........172 to 174
'' '' float level..........168
'' '' ''model D''..........148
'' '' motorcycle..........845
'' kerosene carburetor..........754
'' plain tube carburetor..........800
Schrader tire valve..........550
Scored crank shaft..........642
'' cylinder..........201-202-653-650-587
S. C. or single contact lamp base..........433
Scraping bearings..........642-643
'' carbon..........624
Screw and bolt sizes, S. A. E. and U. S. S..........612
Screw pitch gauge..........700
'' plate and sets..........704-612-613
'' taps..........704
Screws, bolts and nuts..........701
Scriber..........700-707
Scripps-Booth, disconnecting battery..........423
'' '' specifications of..........546
Sea Island cotton, used in tires..........566
Sea level, meaning of..........920
Sealing compound for battery..........439-473-474
'' nut..........439
Sears-Cross speedometer..........513
Seat of a valve..........630-94-92
Secondary cable and wires..........240-241
'' cells..........211
'' coil of high tension magneto..........269
'' current, meaning of (see current)...219-220
'' winding, testing of, on coil..........245
Second change of gears, speed ratio..........13-583-51
'' hand car, how to judge and value of..........528
'' or intermediate speed, how to shift gears..........51-486-488
Seconds, minutes, and degrees, meaning of......93-541
Sectional tire repair..........573
Sedan, meaning of..........15-527
Sediment in a battery..........457-469-456
Segments on commutator..........227
Seized clutch..........661-662
'' piston and how to loosen..........689
Selecting a car..........527-528
Selective type transmission..........46-49-50
Selector..........490-49
Selling automobiles..........529-530
Semi or half elliptic springs.......... 27
Semi-floating axles..........38-532-669
'' '' '' adjustment of..........669-674
'' splash lubricating system..........197
Separators for batteries and inserting of......445-466
Series connection (see ''connections series'')207-214-466
'' dynamo..........335
'' multiple connection..........209-214
'' parallel connection of battery......209-466-214
'' wound motor..........333-335
Set screws..........701
Service car, how to construct..........759
Setting and timing Atwater-Kent ignition..........250
'' breaker or interrupter gap on magneto..264-298
'' ignition (Bosch)..........312-280 to 284
'' '' (Cadillac)..........132-729
'' '' (Delco)..........245-396
'' magneto advance (see magneto)......309-310
'' magneto, armature of..........267
'' '' (Bosch dual)..........312
'' '' (Dixie)..........292
'' '' (Eisemann)..........313-362
'' '' inductor type..........313
'' '' (Remy)..........314
'' '' (Splitdorf)..........313
'' '' use of coupling..........302
'' spark, Chalmers..........357-318
'' '' plug points...235-238-237-298-542-218
'' time of spark..........227-310-316
'' '' '' '' coil with vibrator......315-316
'' '' '' '' with magneto..........311
'' valves, engines of leading cars..........542
Setting valves, illustrated..........102
'' '' of engine (single and multi-cylinder)..103
Shaft drive, advantages of.......... 21
Shaft straightening or arbor press..........618
Sharpening drills..........707
Sheldon rear axle for trucks..........750-751
Shellac, use of and how to mix..........716-738
Shifting gears..........51-486-488-490
Shims for bearings..........74-641
'' laminated type..........641
Shipping a battery, how to crate..........473
'' an automobile..........509
Shock absorbers, air spring or plunger type.......... 26
'' '' Connecticut..........732
Shop equipment and cost of..........617-618
'' hints and useful devices..........730
'' lamp, how to make..........735
'' machinery, how to lay out..........618
'' tools, see ''repair shop''..........615
'' working bench, how made..........617
Short circuit, cause and meaning of..........412-439
'' '' indications..........413-416
'' '' how to locate..........406-416
'' '' indications told by ammeter....417-416
'' '' in secondary winding of coil......398
'' '' of battery..........456
'' '' of starter motor..........406
'' '' tests..........408-413-416-418
'' circuited generator coil tests..........402-416
'' circuiting coil vibrators..........230-264-809
'' stroke engines vs. long stroke..........531
Shunt field circuit..........332-333-335-345-400
'' '' coil test..........403-416
'' '' current (Delco)..........390
'' for testing..........414
'' use of for testing..........416-414
'' winding..........332-333-335-345-400
Shunts in use with ammeters..........414
Shutter for radiator..........188
Shuttle type armatures..........256-258-332-335
Side by side connecting rod..........74-127
Side float carburetor..........145
'' of street to stop on..........584
'' ring rim for tires..........557
'' valve engines vs. overhead..........532
'' valves.......... 90
'' wire tire (solid)..........560
Sight hole on distributor..........310

Signal alarms 515
Signals for stopping, etc. 503-504
Signs or symbols of inches, feet, minutes, seconds.541-93
Sign or symbol of electrical terms....356
Silent chains 87-21-411-728-729-369
" chain adjustments 728-729-411-369
" " adjustment (Cadillac) 729
" " " (Dodge) 369-411
" " chain for driving timing gears....112-118
" " drive for magneto 294
" " looseness, how detected 729
" chains, master or hunting link....728
Silvertown cord tire 559
Simms-Huff electric system on Maxwell.......365-366
Simms magneto, principle of 312
Simplex and Duplex governor 839-841
" engine valve timing 311
Single and succession of spark, explained......225-250
" chain drive 18-47-19
" high tension magneto 276
" jet carburetor 148
" plate clutch (see clutch) 41 to 43-50-663-668-842
" pole switch 430
" spark ignition 248-250
" tube tires 549
" unit electric outfit 340-348
" wire or grounded system (Delco)....383
" " system 425-426
Six and eight cylinder engines vs. four....532
" cylinder engine firing order....124
" " " lap of power strokes....126
" " " magneto 306
Sixteen-valve engine (Stutz and others)..109-104-587
Size and shape of electric lamps....434
" air tanks to use 564
" lamps to use 432
" of carburetor, how to determine....158
" " grease and oil cups....608
" " spark plugs 238
" " valves, inlet and exhaust 91
" " Williams wrenches 611-638
" piston rings on leading cars 609-542
" pulley to use for driving air compressor..568-617
" solid tire to use 560
" tires used on leading cars ....543 to 546
" wire to use (electric) 425-427-428
Sizes and prices of lathes 617
Skew gear, definition of 21
Skidding 495-588
Sled, motor bob type 765
Sleep after hard driving, how to promote....589
Sleeve type valves 139-140
" valve engine and timing of....136-139-140
Slide or caliper rule 700
Sliding throttle valve 153
Slipping clutch 661-663
Slow race, tuning engine for 591
Small tools for the repair shop....614-592
Smith motor wheel 755
Smoke, black, white and blue....202-652-169-580-588
" cause and meaning of color....652
" excess of, due to leaky rings....656
" from muffler 580
" tests 169-652-653
" why white 588
Smoky exhaust 202-652-653
"Sneezing or popping" of carburetor....170-169-578
Snow, how to prevent on wind shield....508
Soap for washing car 507
Soapstone for inner tube 569
Socket wrench 613
" " extension, for rear axle....730-824
" " for Buick, Dodge and Overland....592
" wrenches for Ford 824-795
Solder, soft and hard 711
Soldering 711
" aluminum 695
" 'copper" or "iron," how to use....711-614
" radiator leaks 686-715
Solid rear axle, advantages of 19
" tires 549-560-561
" " disadvantages of 527
" " why not used on pleasure cars....588
Solidity of a sphere 539
Salon touring car, definition of.... 15
Solution (anti-freezing) 193-438
" for battery, how mixed 448
Solutions for cleaning metal 401
Sonoscope, locating knocks with....638
Sooty spark plugs, cause of 283
Sounding bar, testing for knocks 638
Spacers for storage batteries 439-442
Spare emergency rim 551-552
Spark advance, why more on a six....587
" " and retard 67-305-227-314
" " range of 249-319
" automatic advance, reason of....307
" and speed relation 308
" " throttle ball joints 608
Spark and throttle lever movements different cars,
496-487-497 to 500
" " " levers 485-496
" " time of combustion 319
" control 227-249-246
" " and overheating 319
" " automatic 246-249-376-377-383
" " " and hand 246-249-377
" " magneto 305
" " manual 377
" " methods 305
" " why both hand and automatic...246-249
" distance will jump....586-301-304-234
" gap device 739-304-234
Sparking commutator and brushes....409
" occurs when switch is off 421
Spark knock (see knocks)....638-639
" lever and carburetion 67
" " position (Delco) 377
" occurring in two cylinders at same time....284
" plug construction 219-233-238-84-939
" " and coil troubles 233
" " air pump 562
" " for aeronautic engine....238-939
" " cables 299-297
" " cleaning of 235-237-589-592-595
" " connections on magneto 295-296
" " defects 299
" " dimensions 238-239-612
" " for magneto 233-298
" " for vibrator coil 238
" " gap . .233-235-218-238-298-237-542-378-808
" " gap, for magneto use....304-298-299
" gap, for starting engine with magneto
ignition 300
" " gap, too great 299-304
" " gaskets 607-717-238
" " indicates valve condition 586-630
" " leaking around porcelain, test of....238
" " lengths 237-238
" " locations of 235-237
" " long body, regular length, and extension..238
" " metric size 238
" " oil soaked, cause of 652-630
" " one piece 238
" " parts of 218
" " points, distance to set....233-237-542
" " " different kinds 238
" " porcelain 235-239-238
" " S. A. E. size threads....612-238
" " sizes used on different engines....239-612
" " standard sizes of 238
" " taps 705
" " tester 710-302-739-304-418
" " testing of 233-236-237-304-234
" " " under pressure 302
" " too long or too short....237
" " troubles 233-237-299
" " where placed on engine 219
" " wrenches 611-612-238
" regulation 486
" relation to combustion 307
" retard and advance 67-305-227-314
" setting time of 227-315-311
" succession and single....250-225
" time of, relation to combustion....307
" " to occur 307-308-319
" timing, Chalmers 357-318
" " Cadillac 132-729
" " Chevrolet 364
" " coil with vibrator 315 316
" " device 84-225
" " Ford 316
" " Hupmobile 360
" " leading cars 542
" " Overland 359
" " Saxon 364
" why blue or white.... 584
Specifications of leading cars (1918)....543 to 546
" " leading cars (1919)....864G
" " trucks 747
Specific gravity, meaning of....449-489-447
" " of alcohol, kerosene, gasoline, water..585
" " of batteries for starting motor....451
" " " electrolyte, how to determine...449
" " scale (Baume) 452
" " simplified, meaning 447
" " testing . ....451 to 458
Speed changes, method of 51
" control of engine 67-153
" " with commutator or timer....227
" change gears ....45 to 51-670-671
" indicator 700-795-921-536-512
" in miles per hour 540
" motorcycle vs. auto 582
" of air compressor 568
" " a speedometer 512-518
" " electric vehicle 478
" " engine, how to tell....823-700-536-921
" " engine to car, relation of....537-538

Speed of magneto cam 267-271
" " inductor type armature of magneto......265
" " pulleys, how to figure....................563
" relation, crank and cam shaft.............308
" relation of armature and distributor...308-306-261-294
" relations of magneto parts................306
" relation, wheel and engine................540
Speeding up and remodeling old cars........760 to 762
Speedmeter, Van Sicklen 824
Speedometer, principles and drive methods..17-511 to 518
" gearing ratio 587-513
" make used on leading cars..........543
" pointers 742-512
" speed of 512-513
" troubles 512
Speeds of transmission 45-51
Sp. gr. (see index, "specific gravity")...........449
Splash oiling system 197
Splined shaft 669-679-671
Spicer universal joint 680-681
Spilled electrolyte, making up for loss of.........473
Spindles 31
Spiral bevel-gears, definition of 21-35
" springs, how to wind 713
Spirit level 700
Splicing an inner tube 572
Splitdorf-Apelco electric system, on Briscoe........363
" " " " on Mitchell-Lewis..367
" Co., address of 373
" coil connections 228
" "Dixie" magneto (see also Insert)...290-293
" dual system 262
" low tension magneto, coil and battery system and wiring diagrams......262-926
" magneto and setting of.....insert No. 3 and 292-288-313-811
Split rim for tires 557
Split type crank case 62
Sponges 602
Sporting type cars ....760 to 762
Spot light 437
Sprayer for cleaning engine 621-740-744-739
" " painting radiator 194-736-509
Spray nozzle 142-147-739
Spreaders for tire valve................571-555-550
Spring and ball, oil regulation 200-694
" blocks and clips, purpose of..........11-26-27
" cover and lubricator 559
" compressors 663-647-664-742-744-819-932
" how made by winding on bolt 603
" lubrication 622-559
" of valve, method of tying 632
" temporary repair of 734
" under valve when grinding 631
Springs, cantilever 27
" for trucks 749
" " valve 635-92-742
" " valves, proper tension 635-742
" " " of carburetor 146
" full elliptic and half elliptic............ 27
" lubrication of 27-622-749
" spiral, how to make 713
Sprocket chains 21-18 749
" chain tightener (Overland) 648
" wheel puller 647
Sprockets, purpose of 18
Spur gears, where mostly used................. 21
Square, stroke and bore 83
Squeaks and noises 581
"Staggered" cylinders, meaning of 127
Standard adjustments of leading cars.............542
" adjustment of Packard 850
" (S. A. E.) tire sizes 554
" (S. A. E.) threads 612-238-701-702
" speedometer 513
" tread, dimensions of 17
Stand for axle work...........709-730-605-797-824
" " engine or crank shaft work............605
Stanley steam car 763-764
Stanweld rims 557
Starter-generator wiring simplified...............370
Starters for engines 321
Starting a car 486
" an engine in cold weather.......153-155-161-170-489-798
" batteries 441
" engine 65-153-300-487-492-153
" " choking air supply 159
" " on the switch...........489-282-321
" " if starting crank is lost...........591
" " in cold weather...193-170-153-586-804
" " on ignition 282-321-489
" " using magneto ignition.............300
" in auto business 583
" into the automobile garage business......597
" " " repair business 593
" motor (electric) 328
" motor and generator, how combined...347-352-354-379
" " " generator, fly wheel drive......338
Starting motor clutch repair 690
" " Bendix drive 326-331-342
" " Bijur double gear..............328-857
" " cranks engine slowly 408-401
" " current required 410-416
" " different driving principles.....324-326
" " does not work 408
" " electric 324-325
" " fails to start 407-401-331-416
" " Ford 864A
" " gear reduction 328-324
" " gears fail to mesh................407
" " generator and ignition, how combined.348
" " lubrication 331-407
" " tests 416-407-410-424
" " troubles 331-407-408-416-410-424
" " weak 408
" " wire 425-428
" on ignition 262
" operation, Delco...379-384 to 385-395-396-406
" switch, care of 407
" switches 327-329-427-408
Starrett gas heater and tools....696-698-699-700-613
Starvation of battery, meaning of................439
Static electricity 297-162
Stationary engine ignition 215
" engines 757
Stay or security bolts 549
Steam car, Doble and Stanley...........765-757-763
" emits from radiator, cause............860-579
" for carburetion 785
" engines ....757-763 to 765-52-53
" vulcanizer 574-610
Stearns-Knight engine, valve and ignition timing...136
" " re-designing old car 762
" " specifications of 546
Steel and iron, different compositions of 721
" cleaning of 401
" heat treating and case hardening...........696
Steering a car 493
" assembly, purpose of 3-11-24
" column connections 497
" device adjustments ....691 to 693-690
" " bevel type 692
" gear, irreversible 25
" gear mnf'g's addresses 691
" knuckle arms 2
" knuckles, how moved and purpose of....11-25
" mechanism, details of 24-692
" " old style 25
" post puller 736
" wheels, how constructed..............11-692
" wheel, how to hold when driving.........493
Step cut, piston rings 609
" lamp 433
Stewart (Ford) starter 322
" vacuum system 163-165
" horn adjustments 515
Stewart-Warner speedometer 513
Sticking vibrator points 235-808
Still for water 709
Stillson wrench 614
Stock bins 606
" for a die 704
" room, how to construct and supplies....601-607
Stone bruised tire and repair............566-575-573
Stopping a car 495-489
" " magneto 275-276-259-299
" " leak, with sal-ammoniac 713
" engine 489
Storage battery (see also index, battery)....441-864C
" " a chemical generator 210-211
" " and electric starter.............327
" " Cadmium test 864D
" " dictionary of terms.................439
" " floating on the line..........334-337
" " for electric vehicle..........476-441
" " for ignition 210
" " for ignition, advantages and disadvantages 255
" " grounded terminal of.......421-327
" " how charged by generator.......387
" " poles, how to determine......212-452
" " repairs, see battery repairs......456
" " terms 439
" " troubles 421-416
" " voltage 327-416-410-453
" in garage, prices of 599
" system for oil 736
Stove bolts 701
Straightening a bent frame 731
" axle 737-709
" bent crank shaft.......................646
" " valve stem 735
" various parts of car............745-731
" warped pieces 696
Straight side rim 552
Straining gasoline 161-162
" " and static electricity.......162-585
Stream line, meaning of 760

Page
Street and traffic rules 501
" cars, passing of 502
Stripped nut, method of rethreading....709
Stroke and bore, meaning of 81
Strokes of piston 57-116
Stromberg carburetor 176-178-184-927
" float level 167
Strut rods, meaning of 21
Stuck in mud, how released....517
Studebaker and Saxon generator and starter tests.406
" brake adjustment 679
" carburetor used on 172-864H
" chassis 204
" clutch adjustments 665
" disconnecting battery 423
" electric system 244-368-864H-368
" engine 71
" gear shift 499
" lubrication chart 204
" pinion (axle) adjustment of 679
" rear wheel bearing adjustment....679
" spark and throttle control....496-499
" " timing 368
" specifications 546
" steering device 693
" torque arm repair 690
" transmission, adjustment of....670
" wiring diagram 368
Stud broken, how to remove and oversize....709
Studs, taper pins and set screws....701
Stutz carburetion heating method 157
" engine, valve timing and racing engine..108-109
" specifications of 546
Sub-frame, purpose of 11
Submerged motor-generator, method of drying out..409
Succession of sparks and single, explained..225-243-250
Suction stroke 59-116
Sulphated battery plates 439-456-457
" plate charging of battery, to remedy....461
Sulphuric acid for battery 448-449
Superheated steam 785
Supplies for cleaning car 507
" " the stock room 607
" how to sell 595
" needed for battery work 474
Surface of a ball, to find dimension of....589
" type carburetor 142
Suspension of power plant 11
Switch 213-211-275
" Buick 378
" connections for lighting....427-426-428-348
" (Delco) 375
" depolarizer type 246-248
" for magneto and how cut off....275-276
Switches for starting motor....329-427-408
" single and double pole 430
" testing of 253
" touring 427
S-wrench 611
Symbols, electric 356
" of inches, feet, minutes, and seconds....541
Synchronizing points on magneto, cam, distributor.301
Synchronous system of ignition 282
Sylphon for water thermostat....860
Syphon principle 740
" tank radiator 190
Syringe (hydrometer) 450
Systematic trouble-hunting 577

T

Table for cleaning parts 603-741
" of charging rates for battery....467
" " centigrade to Fahrenheit 540
" " conversion, degrees and inches....115-314
" " conversion, hundredths to sixty-fourths in.115
" " degrees 93
" " decimal equivalents 541
" " drill sizes, drills and taps....706-703
" " horse-power 534
" " millimetres 554-540
Tables, miscellaneous ....539 to 541
" spark plug sizes 289
" William's wrenches 288-611
Tachometer 921
Tail lamp 433-17
Tail light law of Ill....857
Taking up bearings on engine....72-640-648-641-838
Tank, compressed air 564
" for cleaning motor parts....401
" gasoline 164-602
" gauge, gasoline 514-823
Tap and drill sizes for S. A. E....703
Taps 427
Taper arbor 706
" pins 701
" reamer 706
" shank drills 706
Taper tap 704
Tappet or plunger of valve.... 92

Page
Taps and dies 704-612-613-795-796
" for spark plugs 705
" how to use 705
" taper, following, and bottoming....704-705
Taximeter, how to read....537
Telephone generator 586
Temperature correction of battery....449
" of battery 448
" " " at end of charge....461
" " welding heat 719
" regulator for carburetor 155-159
Temper colors of steel 697
Temperature of engine cylinders....200-189
Temperature of water control 187
Tempering drills and small tools....697
Tension of valve springs, how corrected....685-742
Tents for touring 516-517-743
Terminals, copper 609
" of battery, color of 421
" " " how to connect 445
" " " reversed 421-417
" " magneto 297
" " storage battery, grounding of....327-421
Testing accuracy of ammeter 398-410-406
" armatures 402-403-406-410-411-412-416-424-418
" " magneto ....301 to 304
" Atwater-Kent system 249
" battery 416-410-450-864E
" battery (for troubles) with hydrometer 457-450-452-864E
" battery with voltmeter..410-416-453-864D-460
" bearings after taking up 641
" board, electric 418-424
" carburetor for dripping....585-167-737
" carburetor mixture 169
" charge of bat. with volt-meter 460-453-461-864D
" coils 234-235-236-249-253-416-418-245-302-398-402-710-252
" compression 629-627-628-739
" commutator 406-404-402
" condenser 303-245-398
" Connecticut ignition system 254
" connecting rod alignment....646-649
" crank shaft alignment 646
" current flow of a circuit....415-416
" cut-out and indicator with ammeter....410
" cylinders for leaks....656
" distance of coil spark....233-234-301-586
" dry cells 241
" electric horn 514-418
" " troubles 416-410
" engine bearings 641-507-838
" field coils 403-416-406
" finish of a ground valve (with pencil marks)632
" float valve of carburetor....737-167-163
" for broken wire 241
" " grounded generator and motor coils 402-416
" " grounds 416-402-403-399-418-406
" " intake valve leak 629
" " knocks 639-790
" " leaks of radiators 191-715
" " loose bearing 646-641
" " loose connecting rod and piston 645-649-638
" " missing explosion....233-236-237-241-249-298-300-808
" " noisy rear axle....739-932
" " noisy valve 685-634
" " open circuits 416-418-402-399-403
" " piston ring leaks 629-656
" " rough commutator 406-404
" " short circuits 403-413-416-418
" fuse 428-418
" gasoline 161
" generator 416-402-403-410-418-424-406
" " voltage 414-410-416
" horse-power 536-537
" ignition advance 317
" ignition coil ....(see testing coil)
" " troubles 233-302-739-301
" inner tube for leak 568-567
" light circuits 403-399-418-413-406
" magneto 302-304
" " magnets 301-303-584-806-864J
" " winding 301-302-303-304
" mixture (carburetor) 169
" motor for internal troubles 416-402-424-410-406
" oils 201
" outfit (volts and amps.) for garage 414-864E-I-J
" outfit, electric ...424-418-410-414-864D-H-I-J
" output, (Delco) & other generators 397-416-410
" piston rings and cylinders for leaks....656
" platinum points, acid test....234-304
" radiators 714-715
" spark 234-418-304-302-710
" spark plug cables (magneto) 299
" spark plugs ..234-236-237-233-302-710-418-304
" speedometers 512

Testing stand, for engine 744
" storage battery 416-410-450-457
" starting motor, current consumption...416-410
" " " for troubles.....404-407-424
" switch (ignition) 253
" transmission shaft alignment....732
" valve cap leak 629
" " and piston clearance.....94-634-649
" " springs, tension of....635-742
" valves with Prussian blue....680
" " if need grinding 680
" vibrator points 234-236
" wheels 682-683
" winding of magneto 301-304
" " (secondary) of coil 234-304-302-245-402
" wire lead from generator for polarity.....421
" wires for polarity 452-421
" with meter for short circuits..402-416-417-406
" " volt-ammeter 398-399-402-414-419-416-410-406
" wrist pin for knocks 638
Test lamp 744-418-403-399-402-864
" " for ignition setting (primary terminal)..729
" " outfit for short circuits, etc.....418-403
" " testing coils 402-304
" points 399-402-403-418
Tests for "motoring" generator (Delco).....400
" " smoke 169
" " short circuits 416-402-403-418-413-406
" of Delco cranking operation 400
" " generator troubles 416-402-403-410
T-head cylinders 81
T-head cylinder vs. L-head and I-head 532
Theft insurance 521
Thermal efficiency 535-587
" principle of generator regulation..339-334-345-350-337
Thermometer for battery 449-450-451
Thermostat 246-249-254-371
" Cadillac cooling system 130-780
" Packard cooling system 860
" electric ignition 246
" electric generator 350
" for water 130-187-191-860-824
" Remy electric generator 350
Thermostatic control of output of generator.....371
Thermo-syphon cooling system 185-186-188
Thickness gauge 697-699-649
" " substitute for 94
Third brush on North-East (Dodge).....370-733-924
" " regulation 389-925-405-370-386-388-393-396-345-733
" change of gears, speed ratio.....13-51-486-488
Thousandths of an inch, explanation of...541-697-699
Threads 702
" for pipe 703-702
" how cut 704
" how to tell pitch of 702
" on S. A. E. spark plugs....612-238
" S. A. E. standard 701-702
" U. S. standard 701-702
Three bearing crank shafts vs. five 581
" cylinder engine, firing order....117
" point suspension 12-72-533
" quarter floating axle 33-669-672-675-532
" unit electric outfit 340-343
" wire system 425-426
Throttle and spark lever movements, different cars....496-487-498-497-499-500
" " spark levers 485
" of carburetor 148-153-154
" valve, butterfly type....146-152-153
" valves, rotary 153
Throttling governor 757
"Throws" of crank shaft 77-122
" " eight cylinder engine crank.....127
" " of six cylinder engine crank.....123
" " twelve cylinder engine crank.....135
Thrust bearings 36
Thumb screws and wing nuts....609
Tickler on a carburetor 145
Tie bolts for battery 439
" rod or drag-link 25
Tightening bearings (see bearings).....641 to 645-838
" belt of fan 187
" bolts and nuts, importance of.....507-593
" generator chain and silent chains..411-729
" nuts on cylinder heads 717
" parts of a car, price to charge.....595
Tillotson carburetor 183
Time for spark to occur....68-307-308-319-314
" per hour expressed in M. P. H....540
Timer 225
" adjustments ....247 to 254
" and distributor 242-245-246-230
" automatic advance 249
" and generator, how combined and driven..246-245
" contacts 245-247-252-254-234-304
" (Delco) 244-245-378-390
" distributor (magneto) 274-276
Timer notches and cylinders 247
" setting of 250-245-390
" where spark control lever is not used.....249
Timing and setting Atwater-Kent ignition..250-810-816
" light and 12 cyl. magnetos....292
" gears 87-111-65-835
" " Chevrolet 636
" " how lubricated 198
" " meshing of, Buick 109
" " " " gears 111-816
" " " " on T-head engine.....106
" " noise in 583
" " relation to valve timing 112
" " removing of, Chalmers....318
" "L" and "T" head engines....105
" magneto, (Bosch dual)....812
" " (Dixie) 292
" " (Eisemann) 285
" " (inductor type) 264
" " (Remy) 813
" marks on fly wheel 104-110-106
" spark on Saxon 864
" the Delco timer 245-390
" the ignition ....305 to 320
" " " (Buick) 245
" " " (Cadillac) 132
" " " (Chalmers) 357-318
" " " (Dodge) 369
" " " (Delco) 390
" " " (Hupmobile) 860
" " " (King) 360
Timing the ignition, (Maxwell) 367
" " " (Mitchell) 258
" " " (Overland) 359
" " " (Reo) 873
" " " (Studebaker) 866
" " " magnetos 310-311-313
" " " sleeve valve engines 136
" " valves and ignition of Chalmers...818-124
" " " by piston 836-108
" " " by fly wheel marks.....836-104
" " " engines of leading cars 542
" " " illustrated 102
" " " of racing engines....108
" where spark controller is used....250
Timken brakes 684-686-687
" rear axles and differential adj'm't..673-674-678
" roller bearings 687
Tinning a soldering "copper" 711
Tire air pressure 553-554
" air pumps 562-563
" attaching and detaching....553-556 to 558
" beads, types of 552-553
" blow-out, repairing of....573-575-567
" blow-outs 567
" care of 565
" carriers 608
" chains 550-551-559-560
" clincher type 552-553-558
" construction 565-564-559
" cord type 559
" cushion type 560
" demountable with rim 555
" dual type 560
" emergency 552
" equipment, modern 551
" equalizing traction 565
" fabric type 566-565
" fabric, cutting of 603-573-610
" first pneumatic rubber 581-582
" fitting clincher bead to a Q.D. rim.....553-586
" for electric vehicle 589
" for airplanes, sizes....559
" for heavy duty 560-561
" gauges 568
" how to find wheel load and carrying capacity.554
" how to save 506-567
" proper inflation pressures....553-554
" leather tread 551-559
" lubrication 569
" lugs 549-550
" manufacturers, addresses of 571
" metric sizes 554
" non-skid 550
" old and new types....550
" oversize 553-554
" paddle wheel type 561
" painting of 509-571
" price for old rubber 588
" pneumatic 549-565
" punctures and how to repair.....567-569 to 574
" puncture proof 559
" pressure for hot weather 553
" pumps....553-562 to 564
" removing from rim ....555 to 558
" repair accessories, tools, etc....610-568
" repairing & prices usually charged 565-571-574-610
" retreading ....566 to 575
" revolutions, per mile 540
" rims ....551 to 558
" S. A. E. standard sizes 584

Tire shoes, outer and inner....................567-568
" side wire 560
" size used on leading cars............543 to 546
" solid 560-549-561-527
" sticks to rim 590
" tool for demountable tire 611
" treads 551
" treads, when worn 566
" troubles, stone bruises, loose tread, etc...566-567
" transposing of 554
" truck, heavy 561
" use repaired one on front wheels...........554
" valve 549-550
" " spreaders 571-555-550
" vulcanizing pointers ....571 to 575-610
" wood plug type 561
"Toe-in" of wheels 683
Toggle type brakes 687
Tool box 606
" for demountable tire 611-568
" for removing bushings...............644-650-824
" for removing gears 302
" hardening 723
" kits 592
Tools for battery work 474
" " blacksmithing 615
" " grinding valves and valve work..632-591-616
" " Ford 795
" " lapping pistons and rings..650-649-657-658
" " scraping bearings 642
" " straightening fenders, mud guards, etc.745-731
" " the lathe 615-711
" " " repairman 592-611
" " " repair shop ....614 to 618
" " tires 610-568-611
" how to keep assorted 594
" for top repairing 847
Too much oil 202-653
Tonneau wind shield 514
Top curtain glass 549
Top, how to clean 508
Top leak, how to repair 847
Top repairing 847
Top repair support 735
Torch, blow pipe 735-615-711-696-712
" gasoline 735-711-712
" gas ....696-4[illegible]3-720
Torsion or torque rods 20-22-13
Torque arm repair 690
" or pull of a motor, testing of 411
Touring accessories 517
" books (Blue Books) 520
" camping outfits 516-743
" equipment (manufacturers of).....518 to 520
" food list 520
" how to build fires properly..............519-516
" inspection before starting 510
" kitchen equipment 517
" personal equipment 518
" switch 427
" trans-continental 515
" trailer 516-747-822
" what to cook and how 518
Towing a car 734-732-518
" truck 732
Townsend grease gun 592-622
Tractors 752-753-829
Tractor carburetion 831-827-754
" engines 831-832-838
" engine ignition 832
" Ford 826
" steering 831
" transmission 830
Traffic rules 501
Trailers 747-746-822-516
Trammel or indicator for valve timing........114-102
Trans-Continental tour 515
Transferring oil from barrel...................730-603
Transformer, relation to coil (see dictionary)274-220-378
Transmissions 45-48-50-669
Transmission, adjustment of, Buick and Dodge.....670
" " " Chevrolet 671
" " " Dort 44
" " " Maxwell 670
" " " Mitchell 271
" " " Overland, Studebaker 670
" air gap principle 481-480
" bearings, replacing of 670
" cause of clashing gears 669
" cause of difficult gear shifting.................669
" changing gears 51-488-490
" dripping oil 669
" drive for generator.................................341
" end play 669
" four speed 47
" gear ratio (see ratio of gearing).............669
" how to remove from car................787-671
" lubrication 203-204-669
" motorcycle 845
" noisy 669-580
Transmission of electricity 206
" on rear axle 47-679-204-670
" operation of 48-50-486-488
" over-hauling of 669-671
" Owen-magnetic 480-481
" pointers 669-671
" replacing bearings in 669-670
" shaft aligning of 732
" tractor 830
" used on leading cars...................543 to 546
Transposing tires (see tires, transposing of)......554
Tread of auto, meaning of 17
" " tires, meaning of 549
Treads of tires when worn 566
" of tires, types of 551
Tremblers, proper name for 220
Trouble, systematic hunting of.......................577
Troubles, Bosch electric systems................361-299
" brushes and commutator 404-409-241
" Delco system ....399-401-402-404 to 406
" digest of 576-142-170-577
" electric, how to diagnose 416-410
" finding by process of elimination.............577
" how to diagnose 576-577
" of armature 411-416-402
" " battery 458-457-422-421-423-864D-416
" " " tested with hydrometer.......457
" " carburetor .. 172 to 184-166-578 to 581-800
" " circuit breaker (Delco) 377
" " clutch ....660 to 665-668
" " commutator 241-325-409
" " cooling systems 189-191
" " cut-out 409-410
" " electric systems 407-416-410
" " electric systems (Overland)..................359
" " electric system (Remy) 350
" " gasoline line 161-162
" " generator 409-411-416
" " " and tests 416-402-403-410
" " ignition ....233 to 237-241-300
" " lamps 419-433
" " lighting system 419
" " lubrication 201
" " magneto ignition 299-300-301-304
" " oil circulation and oil gauge 200
" " piston rings 656
" " spark plugs and coils.........................233-237
" " speedometer 512
" " starting and lighting battery 422-416-864D
" " starting motor 407-331-416
" " storage battery...421-456 to 458-416-864D
" " the ammeter 419-410-416
" " tires 566
" " transmission 669-671
" " valves 630
" " wire connections & wiring system 241-427
" told by ammeter 417-410-416
" worn or scored cylinders...........................653
Truck (army) gear shift 490
" chain driven and worm driven.............14-746
" chains 749-18
" couple-gear electric gas 484
" drive used on modern type.......................749
" (Dodge) 825
" engine ....833 to 838
" (Ford) 825
" governors ....840 to 842
" for oils 739
" for towing 732
" operation of 749
" rear axle 750-751
" tires 560-561-749
" types of 746-747
" wheel, how to remove 741
Truing up wheels 682
Trunk piston 75
T-section iron or steel..................................710
Tub for cleaning parts, construction of............741
Tubing, bending of 713
" flanging of 713
" for tire pump, size of..................................601
" how to saw 710
Tubular radiators 187
Tulip shape valve 92-128
Tungsten contact points 234-304
" lamps, and candle power of........467-432
" valves, hard to grind.......................680-632
Tuning a car for a slow race 591
" an engine for speed 760-817
" engine, price charged 595
Turnbuckle 28-665
Turning down commutator on lathe....................404
Twelve and "twin-six" cylinder, meaning of..53-79-134
" cylinder engine 542-851
" cylinder engine, lap of power stroke...........126
" " " firing order 135
" " " magneto 293-922-918
Twenty-four volt battery, supplying 12 volt lights..466
"Twin City" tractor 830-832

Page
Twin cylinder engine (motorcycle) (insert 3)..755-846
‘‘ six cylinder and twelve, meaning of....58-79-184
‘‘Twin-two’’ engine 587
Twist drills 706
Twitchell air gauge 568
Two cycle engines 756-757
‘‘ cylinder engine, wiring of....................231
‘‘ point ignition 277-284
‘‘ port, two cycle engines 756
‘‘ sets of batteries used with coils 226
‘‘ spark ignition 277-283
‘‘ speed rear axle 483
‘‘ unit electric outfit 340-343
‘‘ wire system 425-426
Type numbers on batteries, meaning of 443
Types of bodies 16
‘‘ ‘‘ brakes ....29-684 to 687
‘‘ ‘‘ clutches 39
‘‘ ‘‘ engines (see also inserts)....................63-70-71
‘‘ ‘‘ gear shift control....................46-49-490

U

Under charging of battery, result....................422
Undercutting mica 404
Under slung; meaning of 11
Unisparker 247
Unit power plant 85-71-70-44-121
‘‘ resistance for charging battery....................463-464
Universal joint adjustments 680-681
‘‘ ‘‘ purpose of 43
‘‘ ‘‘ removal (Chevrolet) 672
Up keep of a car 527
Upholstering, how to clean 509
Useful hints and suggestions 589
‘‘ shop hints 730
Use of engine for brakes 494-583
‘‘ of graphite 205
‘‘ of watch for a compass 516
Using engine as brake 492
U. S. L. battery 444
‘‘ motor generator, principle of....................347
U. S. S. and S. A. E. taps and die sets....................612-613
‘‘ ‘‘ ‘‘ wrench set 611
‘‘ ‘‘ ‘‘ threads 701-702
‘‘ bolt sizes 612
‘‘ nuts and bolt sizes 611
‘‘ screw thread table 703
‘‘ tap and drill sizes 703

V

Vacuum brake 479
‘‘ and gas filled lamps 482
‘‘ system, fuel feed....................163-165
‘‘ tank, adjusting of 165
‘‘ type electric cut-out 843
Valve adjusters (engine) 608-634-791
‘‘ ‘‘ for Ford valves 634-791
‘‘ adjusting, Chevrolet overhead type....................686
‘‘ adjustments (clearance) 94-635
‘‘ air gap 94-95
‘‘ and ignition timing of Chalmers 318
‘‘ automatically operated 88-91-90
‘‘ bushing of guide 634-791
‘‘ cage type ....90-94-631 to 633
‘‘ ‘‘ grinding of Buick....................742-633
‘‘ cap leak 629
‘‘ ‘‘ wrench 738
‘‘ caps 87-634
‘‘ chamber 83
‘‘ (check) for two-cycle engine....................756
‘‘ clearance 94-95-635-110-791
‘‘ ‘‘ of leading cars....................542
‘‘ ‘‘ overhead 94-109-636
‘‘ condition indicated by spark plugs....................630
‘‘ cover, removal of 631
‘‘ ‘‘dual’’ 927-109
‘‘ enclosed 92-121
‘‘ finish, test of 632
‘‘ fitting, new and oversize....................630
‘‘ for inner tube 558-549-550
‘‘ gasoline needle 143
‘‘ guides 92-63-634
‘‘ ‘‘ fitting of 630
‘‘ ‘‘ loss of oil when worn....................737
‘‘ ‘‘ reaming of 634
‘‘ ‘‘ replacing of 634-630
‘‘ grinding 92-91-630-636
‘‘ ‘‘ and reseating 632-94
‘‘ ‘‘ compound 631
‘‘ ‘‘ ill effects of 712
‘‘ ‘‘ overhead type 631-636-91
‘‘ ‘‘ pressure required 631
‘‘ ‘‘ tools 632-633-615-616-592
‘‘ ‘‘ valves in head 90-94-137-686
‘‘ hard to grind (Tungsten) 630-632
‘‘ how to test when noisy....................634-635
‘‘ how ground with drill....................735
‘‘ inlet and exhaust, relative size.................... 91
‘‘ intermittent and rotary motion 87
‘‘ in the head engines....................91-137-636
lag and valve lead 101
Valve lap, meaning of 101
‘‘ leak and loss of compression 629-630
‘‘ lift 95-110-927
‘‘ lifter 92-95-110
‘‘ lifter guides 92-649
‘‘ lifter mushroom and roller type.................... 94
‘‘ lifter or tappet or plunger 633
‘‘ location 91
‘‘ mechanically operated 91
‘‘ mixing (carburetion) 141-756
‘‘ noisy 96-634
‘‘ of engine 89
‘‘ on the side 90
‘‘ operation, Cadillac 128
‘‘ opening and closing period....................100-96-97
‘‘ opens early, back-firing result.................... 98
‘‘ oversize 609-630
‘‘ overhead type 85-88-90-91-94-636-137
‘‘ parts 92
‘‘ pitted 630
‘‘ plunger 92-63
‘‘ ‘‘ guide 92-630-634
‘‘ pocketed 712-631
‘‘ poppet type 91-587
‘‘ port, meaning of 83-756
‘‘ principle, Dusenberg 88
‘‘ refacer 632
‘‘ relation to cam shaft and cams....................120
‘‘ reseating of ....;;631-632
‘‘ rotary type 138
‘‘ sixteen to a four cylinder engine....................109-791
‘‘ size of 91
‘‘ sleeve type 136-140
‘‘ seat 92-630
‘‘ ‘‘ when perfect 632
‘‘ setting (see also valve timing)....................103
‘‘ ‘‘ Buick 109
Valve setting, Weidley engine 137
‘‘ sleeve for tire 555
‘‘ ‘‘ type engine ....139 to 140
‘‘ spring compressor 616
‘‘ ‘‘ how to tie when grinding valves....632
‘‘ ‘‘ lifter 592-631-633-735-630
‘‘ springs 92-635
‘‘ ‘‘ testing tension of 635-742
‘‘ ‘‘ weak or too stiff 635-927
‘‘ stem of engine 92-630
‘‘ ‘‘ ‘‘ tire 550
‘‘ ‘‘ lock nut (tire) 550
‘‘ ‘‘ oversize 609-630
‘‘ ‘‘ reaming 630-634
‘‘ ‘‘ repair, (inner tube) 572
‘‘ ‘‘ seat repair (tire) 572
‘‘ tappet 92
‘‘ ‘‘ guide puller 649
‘‘ ‘‘ lever (Buick) 742
‘‘ ‘‘ wrench 738
‘‘ testing of engine when noisy....................635-634
‘‘ (throttle) 143-153-154
‘‘ time usually open 99
‘‘ timing 95-542-836
‘‘ ‘‘ average 114
‘‘ ‘‘ and timing gears relation of....................112
‘‘ ‘‘ (Buick) 109
‘‘ ‘‘ (Cadillac) 108-729
‘‘ ‘‘ (Chalmers) 318-124
‘‘ ‘‘ checking of 110
‘‘ ‘‘ (Chevrolet) 636
‘‘ ‘‘ (Dodge) 114
‘‘ ‘‘ Dusenberg racing engine 108
‘‘ ‘‘ examples 108-109
‘‘ ‘‘ high speed engines 98-108
‘‘ ‘‘ (Hudson) 108
‘‘ ‘‘ (Hupmobile) 588
‘‘ ‘‘ illustrated 102
‘‘ ‘‘ indicator illustrated 102
‘‘ ‘‘ indicator or trammel 114
‘‘ ‘‘ (Locomobile) 108
‘‘ ‘‘ marks, on fly-wheel..104-107-102-109-836
‘‘ ‘‘ (Marmon) 84-114
‘‘ ‘‘ (Maxwell) racer 108
‘‘ ‘‘ (Mitchell) 106
‘‘ ‘‘ (Packard) 542
‘‘ ‘‘ piston position 836-108
‘‘ ‘‘ position 108
‘‘ ‘‘ (Simplex) 311
‘‘ ‘‘ six cylinder engine 113
‘‘ ‘‘ sleeve valve engine 136
‘‘ ‘‘ (Stutz) 108
‘‘ ‘‘ Waukesha engine 836
‘‘ ‘‘ what governs same 98
‘‘ to tell when needs grinding....................630
‘‘ troubles 630
‘‘ tulip shape 128-92
‘‘ what made of 91
‘‘ when ground, to tell 631
Vanadium steel 721
Van Sicklen speedmeter 512-834
Vaporizing gasoline 155-158

Variable resistance, Delco 392
" " regulation 881-383-384
" spark 311
Varnish, ruined in a barn 590
Veeder hydraulic principle speedometer..........518
Velie specifications 546
Vent hole in gasoline tank, purpose of 162
" " in battery cover 446
Ventilator for window 737
Venturi, explanation of 152
" tube 147
Verifying the ignition timing 817
Vernier caliper and Vernier scales..........697 to 699
Vibrating type electric horn..................514-515
Vibration dampener (for silent chain)..........728
" of engine, cause of 584
" dampener (Packard) 850
Vibrator, (electric), for spark..........220-223-225
" (magnetic), for spark 220-225
" (mechanical), for spark 220-223
" points, fitting & dressing..234-235-229-808-809
" points sticking and testing of..235-808-236
" short circuiting when using master vibrator.264
" adjusting of and kind to purchase..234-808
Vise clamps 710
" combination type and machinists type...613-615
Volatility of gasoline 158
Voltage and amperage, explanation of..........207-441
" " " as applied to generators....337
" at end of a charge..........461-416-410-864D
" of battery 327-447-453-416-410-864D
" " a coil 219
" " battery, electric vehicle..........477-478
" " Delco system 389
" " generator 467-337-410
" " lamps ....432-434-543 to 546
" " storage bat'y. per cell 440-441-410-416-864D
" regulation 345-349-925
" regulator (Delco mercury type)..........380
Volt-ammeter for garage use........414-864H-410-424
" " principle of 398-414-410
" " reading backwards 399-410-414
" " tests 416-419-414-410-406
Volt-meter 414-424-398-399-402-410
" " for testing commutator..........406-402
" " " " storage bat'y 453-410-416-864D
" " test when charging battery....460-453-461-416-410-864D
" " to determine positive and negative pole.453
V-thread 702
V-type motorcycle engines 755
Vulcanizer, electric 572-573-575-610
" for shop use 574-575-610
" gasoline 570
" steam 574-570-610
Vulcanizing inner tubes..........570-572 to 574
" hole in top 847
" meaning of 571-565-564
" tires, sectional method....573-574-610-565
" " wrapped tread method......575-565

W

Wagner electric system on Studebaker..........366
" generator and starter on Saxon..........364
Walden's wrench set 611
Waltham speedometer and clock 518-511
Ward-Leonard electric system..........342 to 344
Warner steering device 691
Warner lens 435
Warped pieces, how to straighten..........696
Washing a car 507-605
" parts, table for 603-622
Washrack for garage 605
Waste 602
" can 602
Watch, how to use as a compass..........516
Water above plates (battery) 645-655-456
" and air for carburetion..........735
" boiling and freezing point..........585
" heats quicker at high altitude..........582
" circulating systems on leading cars..543 to 546
" circulation, heating of........187-191-860-130
" distilled for batteries..........455-474-709
" for drinking when touring 517
" freezing point of 451
" from chalky district..........591-191
" frozen and steams 788
" height of, in radiator 185
" how to add to battery and kind to use.454-455-474
" hose rotting 193
" in crank case 582
" in gasoline 161
" jacketed manifolds 82-164
" manifold cracked 715
" pressure and electricity (analogy)..........206
" " for compressed air 740
" pumps, centrifugal 187
" " circulating 187
" purity of 191
" rheostat 468
" soft and hard 191
" specific gravity of 585
Water thermostat 130-860-191-187
Watts, meaning of 207-431-477
" and candle power of lamps..........467
Waukesha engine (truck and tractor)......833 to 838
" engine, timing ignition 812
" governor 835
Waves and impulses of electric current..........266
" of electric current, peaks of..........256
Weak battery 422
" magnets 308
" spring on commutator brush..........404
Weidley engine and valve grinding 186
Weighted air valves, of carburetor..........150
Weight of cubic foot of water 589
" or pressure of an atmosphere 589
Welding and cutting, prices usually charged...723-725
" cylinders 721-726
" expansion and contraction 720
" flame and regulation of 719
" iron, steel, aluminum, brass, copper...721-723
" outfit and parts of 719-727
" oxy-acetylene ....718 to 727
" pilot light 726
" pointers 726
" pre-heating, preparatory to 721-726
" prices to charge for..........721
" tank stand 726
" tanks, where to obtain 725
" thin castings 723
" torch, lighting of 726
Westcott rear axle adjustment 674
" spark and throttle control 496
" specifications 546
Westinghouse battery and coil ignition....848-846-849
" generator and starter......857-860-846
" " " " on Locomobile..862
" ignition and generator combined.846-847
" " system 251
" rectifier 466
Westinghouse shock absorber 26
" starting method 826-824-828
Weston volt and ammeter 414-864H
Wet generator, how to dry 409
Wheel aligner and alignment..........683-744-787-565
" and engine speed 540
" base, definition of 17
" " long vs. short.......... 17
" load of tires, how to find 554
" lubrication 681-581
" pullers 606-742-787
Wheels, adjustment of front 680-681
" compartive size 15
" out of line, cause tire trouble 588
" removal of 669-679
" revolutions per mile 546
" (see "rear wheels" "front wheels")..679-681
" testing of and trueing up......682-681-688
" why small diameter 15
Which is best car 583
"Whip" of crank shaft 79
Whistle, compression type 514-515
" exhaust type 732-515
White spark 584
" spark and throttle control..........496
" specifications of 546
" metal bushing 78-640
" smoke, cause of 202-652-588
Whitewashing garage wall 786
Whitworth threads 702
Why engine loses power 626
" front wheels turn to the right.......... 28
" racing engines are usually 4 cylinder..........587
Williams wrenches 611-288
Willys-Knight wiring diagram 358
" " specifications of 546
" " spark control and gear shift..........499
Winding, motor and generator 832-833-835
" of a high tension coil 219
" " a jump spark coil 219
" " armature 882-885
" " a coil 240
" " coil, partially short circuited..........237
" " coil, testing of 245
" " Delco armature and field coils....881-887
" " electric motor 828-825
" " magneto 268-249
" " " size wire to use..........246
" " motor and generator..........882 to 885
" shunt and compound 882-888-885
Wind shield for tonneau 514
Window ventilator 787
Wind shield cleaner 786-508
" " rain vision 782
" " how to keep snow and rain off..........508
Wing nuts 609
Winton, specifications 546
Wipe spark, explanation of 215
Wiping a joint 712
Wire 207-240-427
Wire, ampere capacity of 427
Wire connections 427-428-240

Wire for ignition, size to use 428-240
" " **primary circuit** 240
" " **starting and lighting** 425-428
" **gauge** 700
" **grounding of** 213-327
" **how to determine size to use**....427
" **loop connection, how to make** 741
" **low tension** 240
" **of a magneto, how to insulate**....297
" **on a magneto, length and size of**....271-588
" **"00" size for starter motor** 428
" **primary secondary** 240
" **should be marked** 241
" **size to use** 425-427-428-240
" **terminals** 609
" **wheels, address of manufacturers** 762
Wiring a car 425
" accessories ....426 to 428
" battery to start on, dynamo to run on....217
" diagram book ....(see adv.)
" diagram, Briscoe 363
" diagram, Buick 388
" " **Cadillac** 183-396
" " **Chalmers** 358
" " **Chevrolet** 364
" " Delco ....376-379-382-384-385 **388-391 to 396-132**
" " **Dodge** 369-370-923
" " electric horn 515
" " Ford 803-864B-430
" " **Franklin** 362
" " **Haynes** 378
" " **Gray and Davis** 351-354-355
" " **Hudson "six-40"** 382
" " " **"super-six"** 391
" " **Hupmobile** 360
" " King car 360
" " **Locomobile** 362
" " **miscellaneous** 923-924
" " **Marmon** 361
" " **Maxwell** 365-366
" " **Mitchell-Lewis** 367
" " **Oldsmobile** 393-394
" " **Overland** 358
" " **Pierce-Arrow** 349
" " **Reo** 371-372
" " **Saxon** 364
" " **Studebaker** 368
" " **Willys-Knight** 358
" " **four vibrating coils**....226-231
" " **low tension magneto and make and break system**....260
" " **light switch** 429-426-430-427
" " **lighting circuits** 430
" " **multiple switch connection**....429
Wiring for two sets of dry cells....217
Wiring diagrams, (one, two three and four cylinder engines) 223-224-226
" **high tension coil** 229-231
" **high tension magneto** 297
" **of Atwater-Kent system** 249
" " **low tension ignition** 214-216
" **plan of (G. & D.) "grounded switch" and "grounded motor"** 355
" troubles, diagnosing, tests....427-416-418-403
Wisconsin aviation engine ....see Insert
Wooden separator for battery 444
Wood plug tire 561
Woodruff keys 708-709
Woods, dual electric-gas car....479
" " **specifications of** 546
Woodworth leather tread tires 559
Work bench 617-605
Worm and nut steering gear 35-691
" " **sector, steering gear**....25-691
" **drive, principle of** 21-35-32
" **driven rear axle**....82-749 to 751
" **gear drive, removing** 750
Worn bearings 641
Wrapped tread tire repair....564-575
Wrenches ....611 to 613-824-235
Wrench for crank case and shaft bearing....738
" **for spark plug** 611-612
" " **tire rims** 611
" " **valve cap** 738
" **how marked** 611
" " **to find sizes of** 611
" **jew speeder** 824
" **open end** 611
" **S. A. E.** 611
" **sizes for spark plugs** 288-612
" **socket type** 613-824-795-592
" **socket type for rear axle**....780
" **Stillson and Coes adjustable**....614
" **thin** 611
" **U. S. S.** 611
" **Williams** 611
Wrist or piston pin 643-644-73-63
" **pin on Ford** 73-786-643
" **pin, testing for knocks**....686

Y

Yoked connecting rods 75-127-129

Z

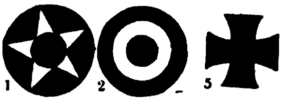
Zenith carburetor, construction and principle....181
" " **gasoline level** 166
" **duplex carburetor** 182
Zero lap, meaning of 101
" **line of current flow**....266-267-309
" **no correction of gravity readings at**....459

ENGLISH-FRENCH DICTIONARY OF MOTORING TERMS

Automobile (small)	Voiturette
Accelerator	Accélérateur
Accumulator	Accumulateur (M)
Adjusting screw	La Vis de règlage
Admission pipe	Tuyau d'entrée
Air passage, hot	Tuyau pour l'entrée de l'air chaud
Air pump	Pompe d'air
Air tube	Chambre d'air
Air valve	Soupape d'air
Alcohol	Alcool
Ascent	Montée
Automatic induction valve	Soupape d'admission automatique
Axle	Essieu
Anti-slipping Device (non-skid)	Antiderapant
Back-fire	Explosion prématurée
Back wheel	Roue d'arrière
Ball bearings	Coussinets à billes
Band brake	Frein à bande
Barrel or pump	Corps de pompe
Ball joint	Joint Sphérique
Batteries (primary)	Pile primaire
Battery, dry	Pile séche
Bearing	Coussinet palier
Bearings, roller	Coussinets à rouleaux
Bell, alarm	Grelot, Timbre avertisseur
Belt	Courroie
Belt fastener	Agrafe pour courroie
Benzine	Essence de pétrole
Bevel wheel	Roue conique
Block chain	Chaine à galets
Boiler	Chaudière
Bolt (hexagonal)	Boulon hexagonal
Bolt (round head)	Boulon à tête ronde
Boltscrew	Boulon à vis
Bonnet	Capôt
Bore of the cylinder	Alésage du cylindre
Box spanner	Clef à douille
Brake	Frein
Brake band	Ruban du frein
Brake drum	Frein à tambour
Brake lever	Levier du frein
Brake lock	Frette de friction
Brakerod	Tige de frein
Brazing	Brasure
Brass	Cuivre jaune
Burner	Bruleur
Breakdown	Panne
Bridge	Pont
Bush	Coussinet
Cam, exhaust	Came d'échappement
Cam, gear	Distribution à came
Cardan joint	Cardan
Centrifugal pump	Pompe centrifuge
Chain	Chaine
Chain wheel	Roue de chaine
Change of speed	Changement de vitesse
Change speed lever	Levier de changement de vitesse
Circulating pipe	Tuyau de circulation
Clutch	Embrayage
Clutch friction cone	Cône de friction
Clutch, leather	Cuir
Clutch spring	Ressort d'embrayage
Cogs and teeth	Dents en bois et en fer
Coil	Bobine
Coil, induction	Bobine d'induction
Collar	Collier
Combustion chamber	Culasse
Components	Pièces détachées
Compression cam lever	Billette de commande
Compression tap	Robinet de compression
Connecting bolt (hollow axle)	Axe creux de pièce d'assemblage
Connecting pipe	Tuyau de jonction
Connecting rod	Bielle
Connection	Embrayage
Contact breaker	Interrupteur
Contact (commutator for breaking)	Disjoncteur
Contact screw, platinum tipped	Vis de contact platinée
Control	Contrôle
Cooling, air	Refroidissement par air
Cooling by water	Refroidissement par eau
Copper	Cuivre rouge
Cord	Corde
Cotter	Clavette de manivelle détachable, coin
Counter balance	Equilibrier
Countershaft	Contre-arbre
Coupling	Accouplement
Coupling pin and nut	Vis et écrou pour jonction d'une chaine
Crank	Manivelle
Crank axle	Arbre des manivelles
Crank case bush	Bague du carter
Crank chamber	Carter
Crank pin	Courillon de manivelle
Crank shaft	Arbre à manivelle
Crank shaft feather (or key)	Clavette

Current (charging)	Courant de charge
Cylinder	Cylindre
Cylinder head	Culasse
Custom House	Douane
Dangerous hill	Descente dangereuse
Differential	Différentiel
Distance recorder	Odomètre
Double-thread	Double filet
Driving axle	Essieu moteur
Driving chain	Chaîne de transmission
Driving pulley	Poulie jante
Driving shaft	Arbre primaire
Drum	Tambour
Dust	Poussière
Efficiency	Rendement
Elastic	Elastique
Electric lamp	Lampe électrique
Electric motor	Moteur électrique
Emery	Emeri
Enamel	Email
Exhaust	Echappement
Exhaust cam	Pignon came
Hill climbing	Gravir des rampes
Honeycomb radiator	Radiateur à nid d'abeille
Horse-power (H.P.)	Cheval-vapeu-
Hot	Chaudé
Ignition, advance	L'allumage avance à
Exhaust cam axle	Axe du pignon came
Exhaust elbow connection	Pipe de refoulement
Exhaust, port	Lumière d échappement de la vapeur
Exhaust valve	Soupape d'échappement
Exhaust valve spring	Ressort du clapet d'échappement
Fan	Ventilateur
Feed pipe	Tubealimentaire
Feed pump	Pompe d'a mentation
Felt	Feutre
Fibre, vulcanised	Fibre vulcanisèe
File	Lime
Flange	Bride
Flexible coupling.	Accouplement flexible
Float	Flotteur
Fly-wheel	Volant
Foot-brake.	Frein á pédale
Fork	Fourche
Frame	Chassis
Freezing	Gelant
Friction	Frottement
Front axle	Essieu d'avant
Front wheel	Roue d'avant
Frost	Gelée
Gauge	Indicateur
Gear	Engrenage
Gear, bevel	Engrenage à biseau, Engrenage conique
Gear box	Boite de vitesse
Gear, change speed	Changement de vitesse
Gloves	Gants
Goggles	Lunettes
Governor	Regulateur
Governor, shaft	Arbre du régula-
Gradient	Pente [teur
Grind, to	Aiguiser
Grooved pulley	Poulie à gorge
Gudgeon	Goujon
Gudgeon pin	Goujon
Guide rod	Tige de direction
Handle	Manette
Headlight	Phare
High-tension current	Courant de haute tension
Ignition, electric, by magneto	Allumage par magneto
Ignition lever	Manette d'allumage
Ignition, retard	L'allumage retard à
India rubber	Caoutchouc
Inlet valve mechanically operated	Soupape d'alimentation
Inner tube (tyre)	Chambré à air
Key	Clef, clavette, calle
Knuckle joint	Joint de coussinet, en charnière
Lamp bracket	Porte lanterne
Leather washer	Rondelle de cuir
Left-handed screw	Vis filetée à gauche
Lever	Levier; manette
Licence	Permit
Lifting jack	Chevre; cric
Lock-nut	Contre écrou
Lubrication	Huilage
Lubricator	Graisseur
Mixture, explosive	Mélange explosif
Motor, four-cycle	Moteur à quatre temps
Motor, two-cycle	Moteur à deux temps
Mudguard	Garde-boue
Needle valve	Tige de contrôl d'essence
Neutral	Neutre
Non-skid (tyre)	Anti-derapant
Notched quadrant	Secteur denté
Oil	Huile
Out of gear	Débrayé
Outer cover (tyre)	Enveloppe
Paraffin	Huile de pétrole
Petrol	Essence de pétrole
Petrol tank	Réservoir à l'essence
Pin, split	Goupille fendue
Piston	Piston
Piston ring	Segment du piston
Piston stroke	Course du piston
Platinum	Platine
Pliers	Pince
Plug, sparking	Bougie
Puncture	Crevaison de pneumatic
Railway	Chemin de fer
Rim (wheel)	Jante
Ratchet	Cliquet
Rear entrance	Entrée d'arrière
Repairing outfit	Trousse à réparation
Retard (to slow up)	Ralentir
Reverse	Marche arrière
Reversing gear	Changement de marche
Revolution	Tour
Rivet	Rivet
Roller	Rouleau
Steel	Acier
Screw-driver	Tournevis
Sheet iron	Tôle
Silencer	Silencieux
Skid, to	Deraper
Soap	Savon
Spanner	Clef
Spare part	Pièce de reserve
Spark	Etincelle
Spindle	Fuseau
Spoke	Rayon
Sprag	Béquille
Shaft	Arbre
Spring	Ressort
Sprocket wheel	Roue à chaîne
Starting handle	Manivelle de mise en marche
Stéering gear	Direction
Steering wheel	Roue directrice
Suction	Aspiration
Solder	Soudure
Square	Carre
Teeth of wheels	Dents de roues
Throttle	Manivelle d' estrangelment
Tool box	Boîte d'outils
Train, goods	Petite vitesse
Train, passenger	Grande vitesse
Tank	Réservoir
Tap	Robinet
Tyre (Rubber)	Caoutchouc bandage
Tyre lever	Démonte pneu
Turn (road)	Virage
Valve	Soupape
Washer	Rondelle
Water circulation	Circulation d'eau
Waterproof	Imperméable
Water tank	Réservoir d'eau
Water jacket	Chemise d'eau
Wheel	Roue
Wire gauze	Toile métallique
Wire rope	Cable; corde de
Wood	Bois [fer
Works	Usine
Workshop	Atelier
Worm wheel	Rue hélice
Wrench (spanner)	Clef

*Airplane Insignia.



1—**U. S. A.:** Blue back ground, white star, red center; 2—**Allies:** **France,** red outer circle, then white, then blue center; Great Britain, blue outer circle, then white, red center; **Belgium,** red, yellow, black center; **Italy,** red, white, green center; 5—**Germany** and **Austria:** Black cross, white background.

***The U. S. A. Airplane Insignia** was formerly a star as shown above, but was changed to a circle, same as (2), but with white center, then blue ring, then red, ring. It is placed on top side of the upper wings and bottom of lower wings. The outer red circle di. is approximately equal to the chord of wing, blue circle ⅔ of chord, and white circle ⅛ of chord. There are vertical red, white and blue stripes on the rudder.

ADDITIONAL ENGLISH-FRENCH WORDS.

Ammeter	Amperemetre
Armature	Induit
Blacksmith	Forgeron
Caburetor	Carburateur
Clutch pedal	Pedale de debrayage
Copper wire	Fil de cuivre
Driver	Chauffeur
Electricity	Electricite
Engine	Engin
Explosion	Explosion
French Chalk	Talc
Full speed	Toute Vitesse
Funnel	Entonnoir
Gas	Gaz
Gasoline	see Petrol
Generator	Generateur
Grease	Graisse
Hammer	Marteau
Hood	Capote
Horn	Corte
Horn bulb	Poire
Horn reed	Auche
Hub	Moyeu
Insulation	Isolation
Jack	Cric
Jet (carburetor)	Gicleur
Lamp	Lampe
Lamp oil	Huile a bruler
Lamp wick	Meche
Link (chain)	Maillon
Magneto	Magneto
Magneto ignition	Alumage par magneto
Map	Carte
Misfire	Rate
Nail	Clon
Nut	Ecrou
Odometer	see Distance Recorder
Oil can	Burette
Overheating	Surchauffage
Pressure (high)	Haute pression
Pressure (low)	Basse pression
Pump	Pompe
Radiator	Radiateur
Rim	Jante
Rope	Corde
Screw	Vis
Shaft	Arbre
Speed	Vitesse
Speed (high)	Vitesse grande
Speed (low)	Vitesse petite
Start, to	Partir, demarrer
Steer, to	Diriger
Switch	Interrupteur
Terminal	Borne
Tools	Outils
Universal joint	Cardan
Valve seat	Siege de soupape
Valve, single	Monosoupape
Vice	Etau
Voltmeter	Voltmetre
Vulcanized	Vulcanise
Weight	Poids
Wire	Fil

AIRPLANES: Different Types. Names of Parts. Control Members and Their Purpose. Instruments. Principle of Flight.

It is not the intention of the writer to deal with this subject in a theoretical manner. Merely the fundamental principles will be treated. See page 933 for Liberty Engine.

Types of Airplanes.

Monoplane is a type of machine using but one pair of wings or planes, or lifting surface, fig. 1, chart 398.

The Biplane is the type using two wings or planes, as shown in the Wright-Martin or Curtiss, chart 399. It is the type used most.

The Triplane is one having three wings or planes, fig. 4, chart 398.

The Seaplane, also called the Hydroplane, and Hydroaeroplane, is the type shown in fig. 3, chart 398.

Tractor type is the type of airplane where propeller (1) is attached to the front, **pulling** the machine through the air—see figs. 1 and 3, chart 399.

Pusher type is where the propeller (1) is back of the wings, or main lifting surface and pushes the airplane instead of pulling—see fig. 2, chart 399.

The tractor type is used most, however, in Europe, there are many "pusher" type machines.

Engines used on airplanes are 4, 6, 8 and 12 cylinder. With Gnome type explained in chart 403, the number of cylinders vary from 7 to 14.

A Twin-Engined Airplane refers to a type of airplane using two engines,—as the Curtiss, fig. 1, chart 399, and the Gotha, fig. 2.

Propeller or Aerial Screw.

This is a subject which interests aeronautical designing engineers, therefore will be treated briefly.

The purpose of the propeller is to pull or push the airplane through the air which is termed the **thrust.**

The principle of the propeller on an airplane is similar to the principle of a screw propeller on a motor-boat, but differs in construction.

The speed of the propeller is usually up to 1400 r. p. m. and propeller in most instances is directly connected to crank shaft of engine.

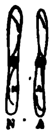
On some machines, the engine speed is higher, therefore the propeller is geared down. For instance, the Sturtevant and Thomas engine speed is 2000 r. p. m. and through a system of gearing, chart 402, the propeller is geared down to 1400 r. p. m.

Twin propellers are where two propellers are driven from one engine by two chains, as on the early Wright machine, as per chart 402.

Propeller slip—when the propeller screws itself forward the air slips past the blades, so that the propeller does not move forward so quickly as if there were no slip. For instance, if a propeller is designed with a pitch of say ten feet, but advances but eight feet, then the slip is equal to 20 per cent.

Pitch—the distance moved forward at every revolution of the propeller, if there were to be no slip, is called the "pitch." The pitch multiplied by the number of revolutions per minute is the distance moved forward per minute. This will be the speed of the machine if there were to be no "slip."

The two-blade propeller is used most and is considered most efficient. **Four blade** propellers are also used, but the two-blade will do the same work. For if a four-blade is used, then the pitch-ratio must be less.



*Two types of two-blade propellers well worth mentioning, are shown in illustrations. One (N), is called the Navy type and the other (A) is called the Army type. The difference between the two is in the curve or camber of blade. The diameter and speed of a propeller has a great deal to do with its efficiency. Therefore the diameter and pitch of a propeller must be designed according to power and speed of engine. Eight and ten foot di. are used extensively, but seldom under six feet.

Thrust means to push or drive with force. Although this is not the technical meaning, we will accept it here.

Control Members.

The rudder is used for steering the airplane to the right or left, called "yawing," or changes direction of motion. It is usually operated by the foot by movement of rudder bar 23, chart 400, which is connected to the rudder (8) by wire cables. Moving rudder to the left causes machine to turn to the left and vice-versa.

The elevators are used primarily for ascending and descending. They are operated by movement of the lever (20), forward and backward. This movement raises or lowers the elevators by connection with lever by wire cables, which causes machine to ascend when elevator is up and descend or "nose-down" when elevator is lowered.

This action is caused by the pressure of wind pocketing against the surface of the elevator which causes a "nose-up" position when up, and "nose-down" position when elevator is down.

Banking, refers to lateral motion or tipping of either side. The movement can be controlled by movement of the lever (20), to either side, which moves the **ailerons** (9, fig. 3, chart 399). By dropping the aileron down, on one side, the air pressure strikes it **underneath**, causing that side of wing to **raise** higher than the opposite side. At the same time the aileron is dropped down on one side it is raised on the other side, which by pressure of air on **top**, causes that side to **lower**.

Copyrighted 1918-1919. by A. L. DYKE, St. Louis, Mo.

---

*Compression of engine not as high on Navy type engines as on Army type (see page 934). The Navy type propeller is often a "pusher" type.

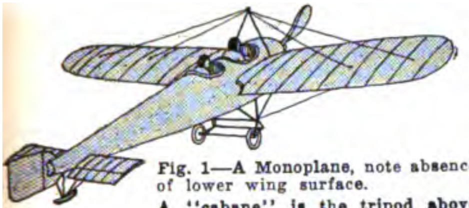


Fig. 1—A Monoplane, note absence of lower wing surface.

A ''cabane'' is the tripod above the wings to which the guy-wire bracings are attached.

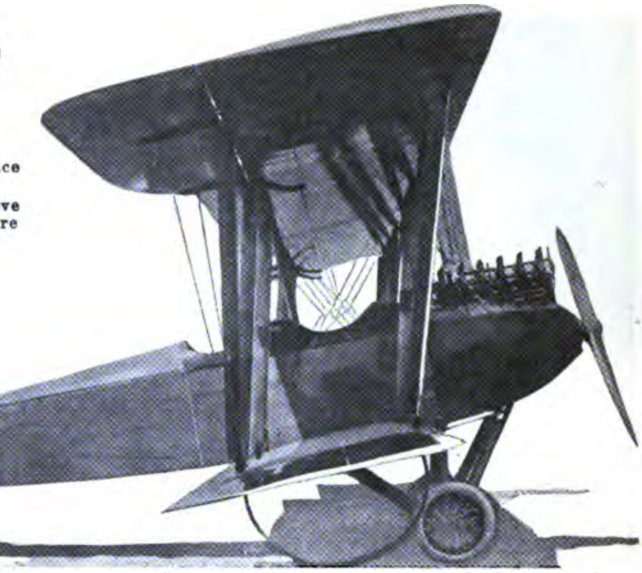


Fig. 2—A modern tractor type Biplane. Equipped with Hall-Scott type A5 engine. Note the **''cambered''** wing and **''staggered''** struts.

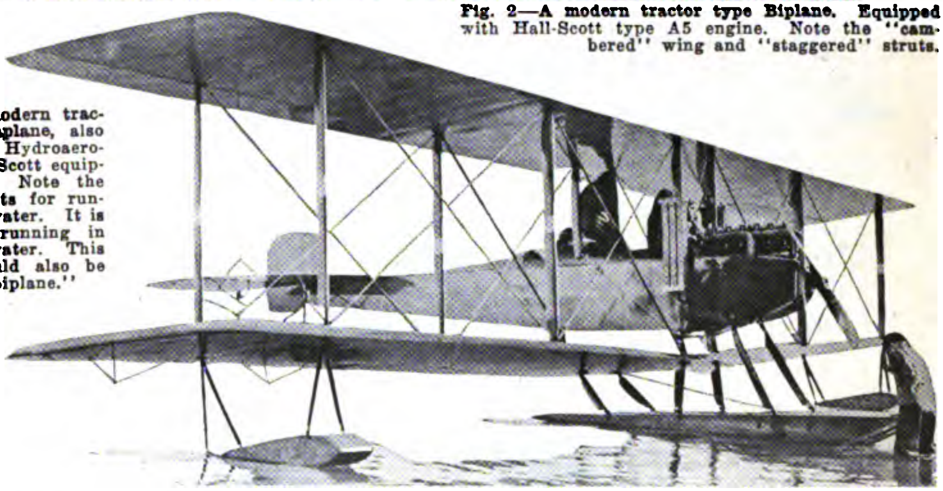


Fig. 3—A modern tractor type Seaplane, also **termed a** Hydroaero**plane. Hall-Scott** equip**ped engine.** Note the **floats or boats** for run**ning in the water.** It is **capable of** running in **the air or water.** This **machine would** also be **termed a** ''biplane.''

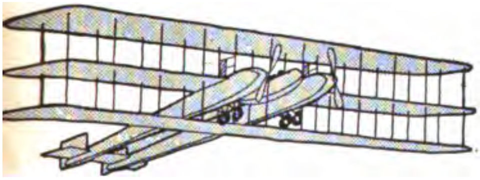


Fig. 4—Triplane—tractor type. Twin-engined.

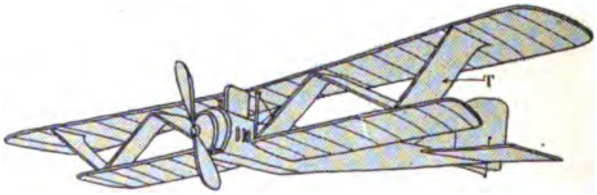
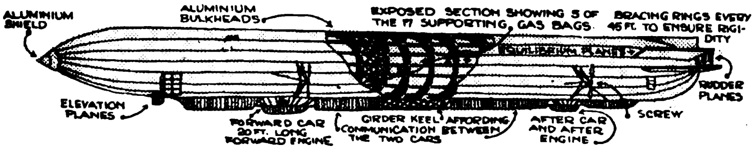


Fig. 5—A biplane, tractor type—with the ''War-en'' truss (T) instead of wires and struts.

Fig. 5.



ALUMINIUM SHIELD
ALUMINIUM BULKHEADS
EXPOSED SECTION SHOWING 5 OF THE 17 SUPPORTING GAS BAGS
BRACING RINGS EVERY 45 FT. TO ENSURE RIGIDITY
EQUILIBRIUM PLANES
RUDDER PLANES
ELEVATION PLANES
FORWARD CAR 20 FT. LONG FORWARD ENGINE
GIRDER KEEL AFFORDING COMMUNICATION BETWEEN THE TWO CARS
AFTER CAR AND AFTER ENGINE
SCREW

Zeppelin Air-Ship.

This type of air-craft would be termed a dirigible, lighter-than-air type—because it is supported in the air by gas.

Engines are located in the forward and aft car swung under the supporting frame-work.

Propellers (screws) are operated by engine. There are four propellers, two on each side mounted above the cars to framework. Power is transmitted through bevel gears. Propellers are three-bladed and 10-ft. di.

Change of altitude is effected by means of two pairs of plane-sets, one forward, other astern; each set made up of four parallel planes, attached laterally, just over the keel.

Gas bags which support the machine in the air are placed as shown, with aluminum bulk-heads between each. Ruberoid is then placed over them and frame-work. If one bag is punctured, others will support craft, by throwing off ballast. The newest Zeppelins are 680 ft. long, 75 ft. di.; 60 m. p. h.

HART NO. 398—Airplanes; Heavier-Than-Air Aircraft. Dirigible; Lighter-Than-Air Aircraft.

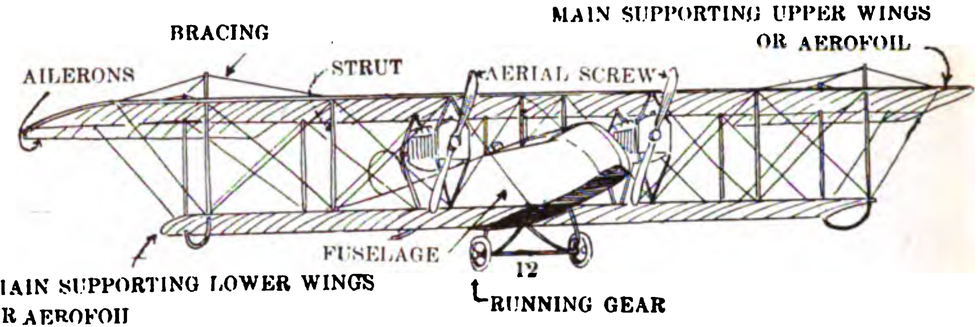


Fig. 1—The Curtiss biplane—tractor type—twin-engined.

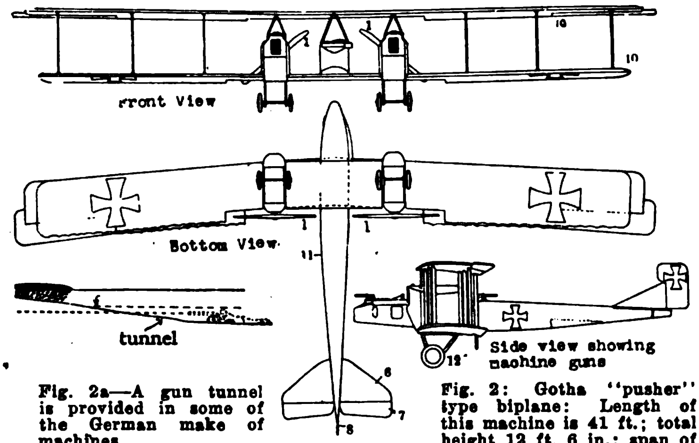


Fig. 2a—A gun tunnel is provided in some of the German make of machines.

Fig. 2: Gotha "pusher" type biplane: Length of this machine is 41 ft.; total height 12 ft. 6 in.; span of upper wings including ailerons 77 ft. 7 in.; span of lower wings 72 ft.; total surface of wings 1000 sq. ft.

Types Of Airplanes.

The illustrations on this page are intended to show the difference between the "tractor" and "pusher" type—also the "twin-engined" airplane.

The Curtiss, fig. 1; there are two propellers, each operated by a separate engine, therefore this would be termed a "twin-engined" biplane. Note the propellers are in front, therefore a "tractor" type.

The Gotha, fig. 2; is a "twin-engined" biplane, but "pusher" type propellers, which are placed in the rear instead of the front.

The Wright-Martin, fig. 3; there is one propeller placed in front, therefore it would be of the "tractor" type biplane.

Parts Of An Airplane.

1—aerial screw or propeller.

3—radiator.

5—cock pits.

6—fixed horizontal stabilizer.

7—elevators.

8—rudder, which is hinged. Directly behind the rudder is the rudder fin.

9—ailerons—on some machines there are ailerons on both upper and lower wings.

10—the wing surface, also termed upper and lower plane or aerofoil; the aerofoil, however, indicates the difference between an ordinary surface and one inclined at an angle to the direction of motion, having thickness and cambered or curved.

11—the body; the fuselage is the framework separate from the wings.

12—chassis or landing gear—see fig. 1.

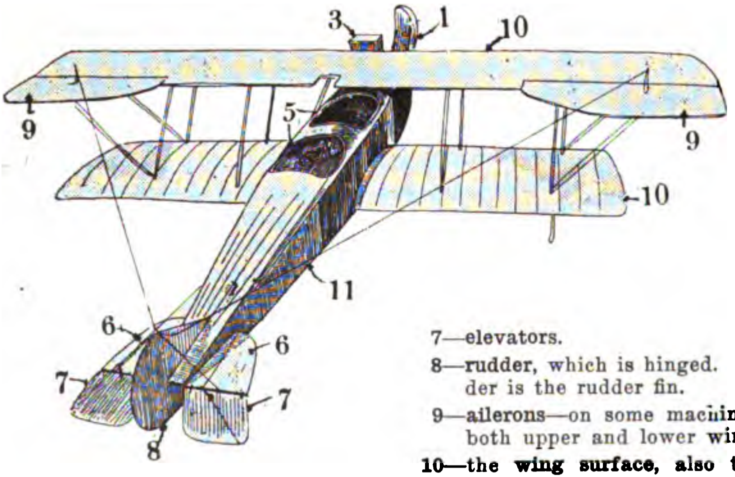


Fig. 3—A biplane—tractor type.

On some types of machines the ailerons (9) are operated simultaneously with rudder. For instance, in turning to the left, right aileron is lowered and rudder turned to the left, tilting or "banking" machine to the left, and vice-versa. It is always necessary to "bank" machine when making a sharp turn.

CHART NO. 899—Airplane; Types and Name of Parts.
ustrations from Motor Age and Automobile.)

Lateral motion can also be controlled by **warping or twisting the main lifting surface or wing, which increases or lessens the angle to which the "leading edge" (fig. 9, chart 401), offers to the wing. This warping of the wing is now seldom used, the ailerons having taken the place. Many machines now have ailerons on both upper and lower wings.

Stabilizer (6, fig. 3, chart 399) is for the purpose of preventing airplane from assuming a vertical position—especially when wings at front are at an extreme angle to the wind. In other words, the stabilizer buoys the tail up when flying. See page 907, for further explantion of stabilizers.

Brief Explanation of Ascending and Descending.

When starting a flight, aviator enters cock-pit, fastens safety belt. Engine is started. Airplane then rolls swiftly over the ground and with a run of about 100 yards, skimming the ground, the control (20) is moved towards him. This motion causes elevator surface (7, fig. 3, chart 399) to be tilted upward to line of flight and airplane ascends. The start should be made **against** the wind.

Starting of engine is usually by turning propeller. A number of modern airplanes are equipped with the starting system explained on page 321. When engine stops in mid-air, if not equipped with a starter, the aviator then glides or spirals down. High compression engines can not be started by movement of propeller with air. It is stated that the Gnome will start in this manner.

The ascension can be made in a forward or spiral motion. If a spiral, at reasonable height, then one side is "banked" or tilted by movement of lever (20) to the right or left side. If the turn is to the left, the right aileron is lowered, which causes the air to "pocket" against the aileron surface, creating pressure, therefore the right wing is raised higher, at the same time the rudder is turned to the left. The elevator is raised sufficiently to keep the wing surface at the proper climbing angle.

†**When descending**, engine is throttled down to about 250 or 300 r. p. m. and machine is "nosed-down" by movement of elevator down. Descent is made with a straight forward glide or wide circle or spiral, by movement of aileron or rudder. When within landing distance, the machine is "straightened-out" by movement of elevator. This straightening effect, causes the machine to check its descension by a sudden air pressure under main wings. By skillfully manouvering of elevator, the machine, after skimming over the ground, finally stops with tail-skid striking the ground first. (fig. 8, page 906). The wheels touch the ground last. Engine is then stopped. **Landings are always made against the wind.**

It is difficult for the beginner to judge just where to "straighten-out" preparatory to landing. When he straightens out too soon, this often results in a novice landing "tail-heavy," breaking the tail skids. When he does not straighten-out soon enough, the result is the wheels strike the ground, and this braking effect causes the plane to "nose-over," breaking propeller and bending engine crank shaft—see fig. 30, chart 401.

When engine stops in mid air, the usual procedure is to "glide" or "spiral" or "volplane" to ground, as explained. Landing is just as easy as if engine was running, except one must take chances on condition of ground where he lands.

Gliding is a straight forward down movement just steep enough to assume effective control of the ship with power off. This is also called **volplaning**.

Principle of Flight.

There are two essential factors necessary in order that the airplane, a heavier-than-air machine, rise from the ground. They are **thrust** and **lift**.

There are two factors which offer resistance to the airplane rising from the ground, they are known as **gravity** (resistance downwards) and ***drift** (resistance horizontally, **also** known as "head-resistance.")

The aerial screw or propeller produces the thrust through the air, which overcomes the resistance or drift. The **lift increases** as the speed of the thrust increases, therefore **gravity is overcome** and result is the wings have a lifting effect, produced as will be explained.

It is well to note that, for an airplane to be supported in the air, it is essential that it be kept in motion through the air and not by the motion of the air past the airplane stationary. In other words, the mass of air engaged, the velocity and force the wing surfaces engage the air, is the theory advanced for the support of the plane in the air.

How this lifting effect is brought about, is explained as follows:

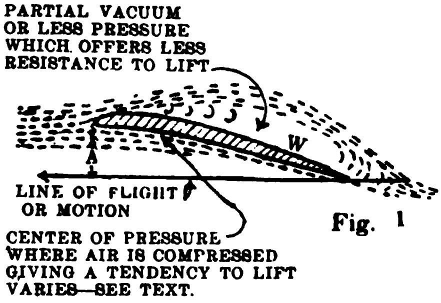


Fig. 1

Supporting and lifting effect under wing: The wing surface is (W). The horizontal line we will call the direction of "line-of-flight-or-motion." The dotted lines represent the wind or air current, and at another point, say one-third of the way back from front or leading edge of wing tip, is the "center-of-pressure" or (C. P.—which varies, as will be explained later). As the bottom of the wing meets the air, it results in

---

†The purpose of running engine slowly was to have power to ascend again if the landing was not favorable. The machine will slightly nose-down when power of propeller or thrust is off. If nosed-down too much descent will be too rapid. ****Warping of wing tips** is a similar action as lowering the aileron and for same purpose, see chart 402.

*Drift also refers to resistance offered by the shape of wings, struts, etc., or any other factors which would have a tendency to oppose lift.

*A spiral is made when space is limited in landing. A glide [illegible]

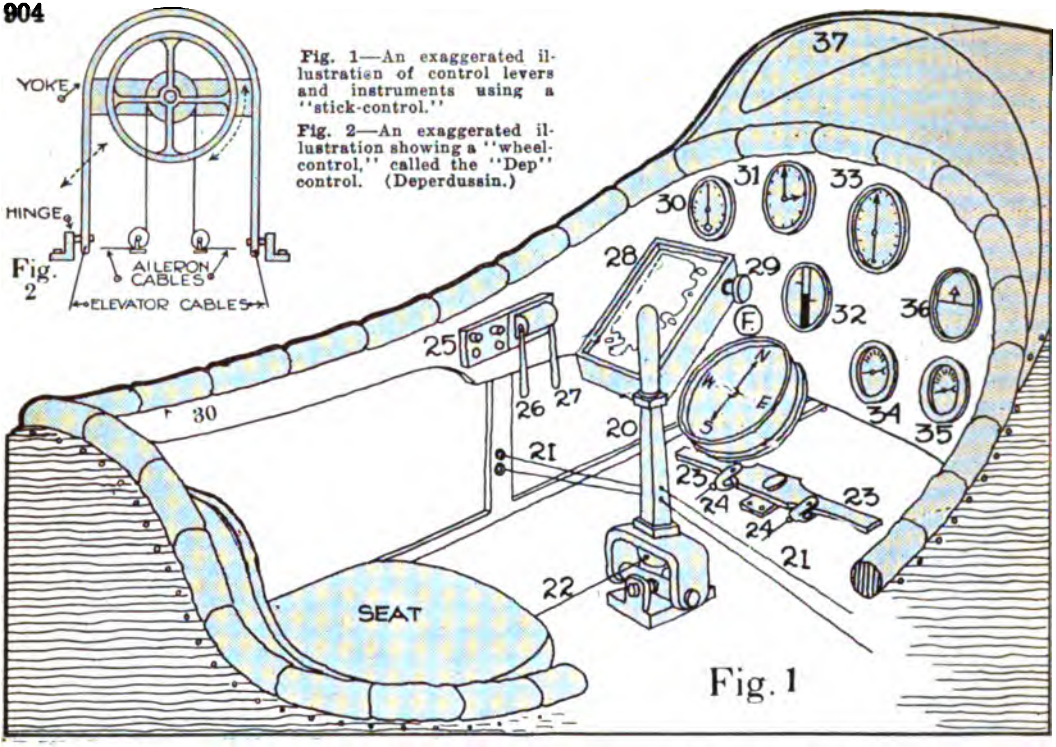


Fig. 2

Fig. 1

Fig. 1—An exaggerated illustration of control levers and instruments using a "stick-control."

Fig. 2—An exaggerated illustration showing a "wheel-control," called the "Dep" control. (Deperdussin.)

Name and Purpose of Control Levers and Instruments.

20—Control stick (on many machines a wheel control is used as per fig. 2). This lever controls the movement of ailerons (9, chart 399) by moving to either side. By moving forward and back it operates the elevators (7, chart 399).

21—Aileron cable or wires; **22—Elevator cable** or wires; **23—Rudder foot control; 24—Rudder cables; 25—Ignition or magneto switches; 26—Carburetor throttle lever; 27—Ignition advance lever; 28—Map holder; 29—Thumb nut** for rolling map.

30—Tachometer, similar to a speedometer. Indicates number of revolutions of engine crank shaft, connected by flexible shaft; **31—Clock.**

32—Temperature thermometer, or indicator, is for the same purpose as the "motor-meter," explained on page 188. This instrument, however, instead of being placed in the top of the radiator cap, is placed in view of the aviator by connection of an extension pipe. It is also often installed directly in the water pipe, coming from the cylinder nearest the propeller. Due to the fact that if water becomes low in radiator, it does not operate properly—hence reason for placing it in the water pipe.

33—Altimeter, which indicates the height. The barometer of the aneroid type is also used for this purpose which indicates the height by indicating the density of the air. The higher the altitude, lighter the air and less the gravity.

34—Oil pressure gauge, indicates oil pressure of engine oiling system.

35—Gasoline gauge, indicates pressure of air in gasoline tank. The pressure fuel system is in general use, per page 854 (see also page 909).

36—Banking indicator, stands at zero or center when a machine is on a level—when wings bank or tip to the side, the needle moves accordingly from either side of zero. This instrument is also termed an Inclinometer.

The Inclinometer, in other words, indicates angles, and is nothing more than an arched spirit level. One is mounted to show angle at sides or lateral stability (side tips), and another could be mounted to show the horizontal stability or "nose-down" or "tail-down" position (the air speed indicator is also suitable for this)

37—Wind shield; F—Compass, indicates direction.

Air speed indicator, a type called the "Foxboro," (not illustrated) consists of a very strong and accurate low-range indicating differential pressure gauge. Indicates the air pressure. For instance, a nose-down direction will show an increase of air pressure and a tail-down a decrease. Therefore, in a way, it serves as an inclinometer.

The instrument is located at any current point to be observed by the pilot, and is connected to a Pitot tube or nozzle by means of smooth copper tubing.

The scale on the indicating part of instrument is calibrated to read in the unit of miles per hour, this being the relative wind or force, acting against the planes of the machine and holding it in the state of buoyancy.

The nozzle is especially calibrated for use with these instruments, and is usually located on one of the forward midwing struts with the nozzle pointing in the direction of motion, so made that water or moisture cannot enter. (see page 800 for principle of Pitot tube.)

The throttle lever is used to govern speed during flight. **The spark lever** is retarded when starting engine on the ground and advanced after engine is started and then advanced and left in this position.

There are usually two magnetos for engine, a separate switch is provided for each ignition unit.

Control movements: To ascend, pull lever (20) back, this places elevator **up. To descend,** move (20) forward, places elevator **down** position. **To balance machine if inclined to right,** move (20) to the left side, this lowers right aileron, which causes right wing to raise. To **balance, if inclined to left,** move (20) to right side, this lowers left aileron, causing left wing to raise. **To turn to right, first** "bank" or tilt machine to the right, by moving (20) to the right side, lowering aileron on left, raising left wing, then move rudder to **right** by movement of rudder bar (23), right side. **To turn to the left,** "bank" to the left and rudder **to the** left. **Neutral position;** elevators are level **position** also ailerons and 23 and 20 in vertical **position.**

CHART NO. 400—Control Levers and Instruments. See also page 921.

At high altitudes the air is lighter or less dense, therefore lack of air causes a decrease of about ten per cent of engine power at and above 6000 feet. Carburetors are designed with air openings which can be opened wider at high altitudes in order to increase air supply to carburetor.

the air striking the under part of wing, when it is compressed, causing it to **push up against the under surface of the wing and is gradually diverged downward, thereby giving the wing its **supporting** effect.

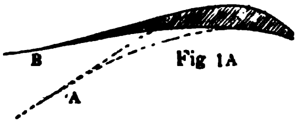


Fig 1A

This is further demonstrated by the wings of a gull (fig. 1A). We will assume that the gull is making a flight in a horizontal direction as per "line-of-flight" (fig. 1). The wings would assume a horizontal lifting position as shown, (B).

Lifting effect above wing. Over the upper surface of the wing the opposite action is taking place.

Instead of pressure above the wing, a **partial vacuum** is created by the air striking the forward edge of the wing and being deflected upwards and over a greater part of the wing surface as shown in fig. 1. In other words, meaning that there is very **slight** air pressure above. The result is that if the pressure below the wing is greater than above it, and a partial vacuum is created above the wing, the mass of air engaged under the wing by motion produced by the thrust of the propeller, will cause the wing to have a **lifting** effect. This is the fundamental principle of flight.

To demonstrate the theory that a partial vacuum is created above the upper surface of a curved wing; take a sheet of paper and hold it as shown in illustration fig. 1B. If you blow horizontally on the edge at B, along the upper face, the rear of the papor will rise (L). Blowing along the under surface will be found to have a much less steady effect in lifting the rear end.

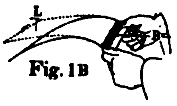


Fig. 1B

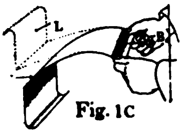


Fig. 1C

If we now hinge the rear (fig. 1C), at about ¼ of its length and curve it down, blowing along the upper surface of the sheet, the rear hinged portion will lift almost vertically in the air and right in the face of the wind, whereas if the hinged portion be kept flat it will not lift, and if rear end is curved upward it will only vibrate and act as a drag to the lifting effect of the sheet or plane forward of the hinge.

This brings out the fact that a curved plane is necessary and the hinged portion explains how the ailerons give a lifting effect to that side of the plane when lowered.

There are a number of factors that must be considered in order to obtain the best lifting effect. Two particularly, are the curve or "camber" of the wing and the "angle" it is placed in relation to the "line-of-motion" or flight, as will be explained.

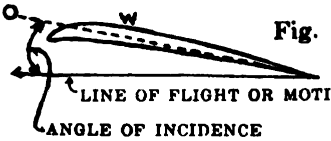


Fig. 2

Angle-of-incidence; W, is the wing; O, is the center line of wing from which we will base our angle. The line-of-flight or motion is shown below it.

The angle between this line (O) and the line-of-motion is termed the "angle of incidence" and right here, together with the curve or camber of the wing, is what governs the lifting capabilities of an airplane, of course assuming that the thrust is equal.

Camber of the wing, or the curve, is necessary on top as well as on the bottom. The camber varies with the angle-of-incidence. The greater the velocity, the less "camber" and "angle-of-incidence."

For great lifting at steep incline or angle, the wing with a greater curve or camber is designed. But, when a wing is designed for great lift, speed is sacrificed.

For great speed, the wings are not cambered or curved as much. When designed for speed, then extreme lift per square foot of surface is sacrificed.

Airplanes designed for high speed cannot land at slow speed.

Airplanes designed for landing slow and safe and getting off the ground quickly, then sacrifice high speed.

When airplanes are slow speed they are likely to encounter "air-pockets"—meaning that if a gust of wind traveling at a greater *speed increase than the flying range of the airplane, should strike the airplane from the rear when flying, the result would be that the plane would drop, due to the air support being taken out from under the wings. To overcome this, the aviator "noses-down" until greater speed is obtained when he "straightens-out" again and assumes his climbing angle.

The aim of designers therefore, is to produce a machine which will get off the ground quickly, lift, have maximum speed and land at a safe speed.

The lift decreases at higher altitudes, due to the fact that the air is lighter or less dense, which affects the operation of engine. There is also a limit to the climbing altitude of a machine, for instance, it will be seen that the higher speed the plane is put to, the greater will be the pressure below the wing and also the vacuum above, so that after the vertical pressure on the wing equals the weight of the machine, any further pressure on account of higher speed would tend to flatten out the angle at which the wing is flying, reducing the angle, bringing it more to a straight line, causing the airplane to travel in a horizontal line instead of lifting it upwards.

**The air must meet the wing surface at such an angle that a downward velocity be given to it after the plane has passed over it. The actual velocity required will depend upon the weight to be carried and the supporting surface that is used.

*It is rare that a wind gust appears with over a 20 miles an hour increase in air speed, so that if any plane today has a speed range of 20 miles per hour—say from 40 to 60 or 50 to 80—this plane is practically free from the effect of this type of "air pocket." (from "Acquiring Wings"—see foot note page 907.)

Empennage.

The empennage is the tail assembly.

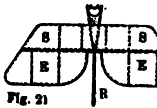


Fig. 21—Top view of rear control members: **S**—stabilizers; **E**—elevators which are hinged and operated from seat by control (20, chart 400); **R**—vertical rudder, operated by rudder foot bar (23).

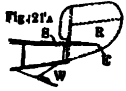


Fig. 21A—Side view of above. The tail-skid (W) is a form of shock-absorber, which prevents damage to rear when landing.

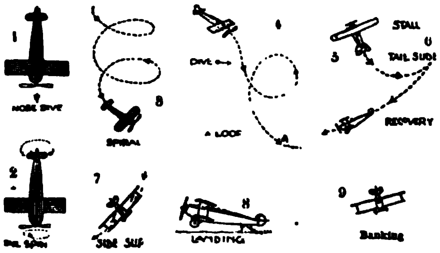
*Flying Terms.

A nose-dive (1); occurs when a descent is made at too great a speed and too steep an angle, so that supporting pressure is lost.. Considerable rudder and elevator action is necessary to place machine horizontally again.

Tail spin (2); machine in vertical position, tail-up and being turned in a spiral, due to several causes. One cause, is due to failure of rudder or elevator to operate, after making a "nose-dive," causing machine to be forced into a small spiral—a very bad and dangerous predicament.

Spiral (3); to descend or ascend in a spiral or wide circle.

A loop (4); speed is gained by a steep dive, then with movement of elevator the loop is made with power on. After looping, elevator is used to straighten out.



Stall (5); when trying to climb at too steep an angle, new pilots sometimes allow their machines to slow down below their supporting speed, when they "stall" and drop tail-first or "tail-slide" as shown. This used to be a dangerous happening, but if sufficiently high in the air, modern stable type machines will recover as shown in dotted lines (recovery).

Side-slip (7); caused generally by taking a turn with insufficient banking, which causes the wings to lose their sustaining effort, once forward motion is stopped. Fliers who know how can now slip for hundreds of feet and right themselves safely (see page 907).

Banking (9); means that the machine is tilted to right or left side. Necessary in turning. Too great an angle will cause a slide-slip (7). See page 960 for method of banking.

Landing.

The proper method to land is per (8) above, and per page 903—tail first.

Fig.29

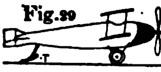


Fig. 30

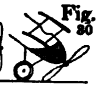


Fig. 29—When landing, "tail-heavy," the tail skids (T) are broken.

Fig. 30—When landing "nose-heavy," due to not straightening out soon enough (see page 903), the propeller is broken and crank-shaft bent. These are common occurrences in training schools.

Dihedral and Aspect-Ratio.

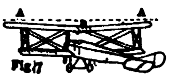


Fig.7

Fig. 7—The Dihedral angle of an airplane is the upward tilt given to the wings, or the angle they are to each other as shown at A. Note (B) in center is lower. The purpose is to assist lateral stability. Quite often it is possible to tell the make of machine in the air by its "Dihedral," as this varies on different makes.

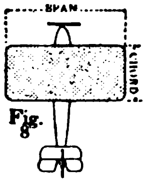


Fig. 8

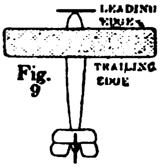


Fig. 9

Fig 8—A low-aspect-ratio airplane. Note the "chord" or width of wing is broad and "spread or span" is short.

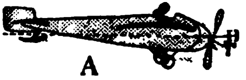
Fig. 9—A high-aspect ratio airplane. Note the "chord" is narrow and the "span" is long. The spread or span divided by the chord gives the aspect-ratio. The same area surface is in each. Large slow machines usually have high-aspect-ratio and speed-scouts, low aspect. See page 907. The high aspect is most efficient.

Leading edge, is the front part of wing; **trailing edge**, rear.

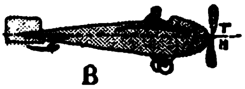
Horizontal and Climbing Angle.

A—Horizontal flight; the propeller thrust (T) is slightly below the horizontal line (H). Although this would appear to be descending, the thrust of propeller, when wings are at a low angle, would have a tendency to keep machine in a horizontal position. This gives greater speed when flying at low altitudes in a horizontal direction.

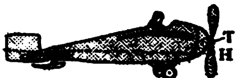
B—Low angle of climb; the propeller thrust (T) is now horizontal, also line (H). This gives a slight increase of angle to wings, therefore there would be a slight angle of climb at low altitudes. The speed is less however, as the increase of angle of wing surface to the air produces greater lift but less speed.



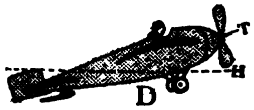
A



B



C



D

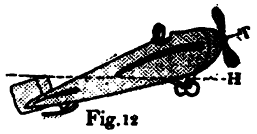


Fig.12

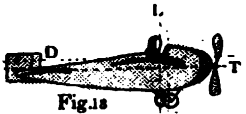


Fig.13

C—Climbing angle; the propeller thrust (T) is now slightly above the horizontal line (H); which gives a slightly greater angle to the wings. This is considered the best climbing angle. The speed however is less than in (B), as the resistance is greater.

D—Extreme climbing angle; the propeller thrust (T) is now considerably above the horizontal line (H). The angle of wings is increased still more—result is greater lift or angle of climb, but resistance is still greater, therefore speed is less than in horizontal climb and B & C climb.

Fig. 12—Excessive climbing angle; the wings are now placed at a still greater angle. The center of pressure (CP) works to the rear of the wing, giving a tendency to oppose the thrust by the wind pocketing at the rear and trying to raise rear of curved wing which causes great resistance therefore considerably less speed and the machine instead of climbing will move horizontally (or stall, page 907).

If the angle is increased to a greater extent the center-of-pressure will work out from under rear of wing, as explained on page 905, and result will be a drop.

Note; illustrations are exaggerated in order to more clearly explain the ill effect of climbing at too great an angle.

Fig. 13—The **thrust line** (T) is the line running from rear, through center of propeller. The **lift line** (L) is the line slightly back of the **gravity line** (G). The gravity line is or should always be slightly forward of the lift line, due to the fact that the machine should be "nose-heavy" and not "tail-heavy" when gliding, with power off. When power is on the thrust overcomes this tendency of nose-heavy. In other words if the power is off it is important that the machine descend "nose-down" instead of "tail-down." The **drift line** (D) is above thrust line.

HART NO. 401—Miscellaneous Airplane Information.

---

*Several of these illustrations from Acquiring Wings—see foot note page 907. See page 93 for explanation of degrees.

When climbing, there is a minimum and a maximum angle. The minimum angle gives the greater velocity and maximum less velocity. Too great an angle would cause machine to fall—because the center of pressure would be changed as explained in the next paragraph.

Center of pressure is continually changing. For instance, when the "angle-of-incidence" is about 7 degrees between, the line (O) and line of motion (fig. 2); as this angle is increased, the center of pressure moves toward the **rear**, therefore, if angle is too great, the center of pressure would move from point where it would properly support the wing surface and result would be a fall.

Fig. 4

Fig. 6

Fig. 4 A stabilizer wing is usually slightly curved at both ends.

Fig. 6. A wing for the control surfaces, are usually double convex type.

Purpose of stabilizers; if center of pressure moves **forward**, the rear of machine has a tendency to drop, tail-down, therefore stabilizers (6, fig. 3, chart 399) are provided to assist in stabilizing or balancing the rear, also prevents pitching forward. This is known as "longitudinal stability." Stabilizer wing surfaces—see fig. 4.

Lateral stability is necessary to prevent side tipping. This lateral balance is usually maintained by "warping" the wings or movement of the ailerons, the latter method being used mostly. On monoplanes the warping method is used extensively.

Directional stability applies to an airplane being thrown out of its course of travel, for instance, by a sudden heavy gust of wind. When turning sharply, it is necessary to make a steep "bank" (tilting sidewise). If this banking is extreme, then the plane "side-slips" or falls (page 906). This is overcome by operating the controls and "nosing-down" until speed is gained then "straightening-out."

GLOSSARY.

AERDROME—a field or grounds used for flying purposes.

AEROFOIL—a cambered, or curved wing, or the lifting surface—but curved.

AERONAUT—one who follows the profession of flying.

AEROPLANE—a machine used for flying, which is power driven and heavier than air.

AILERON—a wing of smaller size placed usually as shown in fig. 8, chart 899. Produces a side or lateral tilt.

AIRPLANE—same as aeroplane.

AIR-RESISTANCE—the resistance offered to the thrust of the machine—approximately four times as much power is required if it is desired to double the speed.

AIRSHIP—a balloon type, lighter than air.

ANGLE OF INCIDENCE—the angle that the line (O), page 905, fig. 2, makes with the line of motion or flight.

ASPECT RATIO—if a wing is six times as long as it is deep, having a spread or span equal to six times the chord, it has an aspect-ratio of six, which is about the average for training biplanes. Anything much above this would be called a high-aspect ratio, whereas wings three times as long as they are deep, would be said to have a low aspect-ratio. See figs. 8 and 9, page 906.

AERIAL SCREW—the propeller.

BANKING—a term applied to the side tipping of an airplane when turning.

BAROGRAPH—records the altitude reached.

BAROMETER—the aneroid type indicates the altitude by density of the air.

CAMBER—a curved surface usually applied to the curve of the wing or propeller.

CENTER OF GRAVITY—a vertical center line which would be termed the weight center.

CENTER OF PRESSURE—a point under wing, from front edge where pressure is centered to greatest compression or balance.

CENTER OF THRUST—a line running from center of aerial screw to rear, fig. 13, page 906.

CHORD—the width of the wing.

DENSITY—compactness; mass of matter per unit of volume.

DRIFT—this word and resistance are analogous, applies to the resistance offered to a machine when moving forward.

DIHEDRAL—see fig. 7, chart 401.

ELEVATOR—a small wing (see fig. 8, chart 899), for ascending or descending.

FORCED LANDING—a landing necessitated by reason of impaired engine.

FUSELAGE—the framework of an airplane, see fig. 8, chart 899.

GRAVITY—the force which draws a body to the earth. The higher the altitude, less the gravity.

GLIDING—a term used when descending with power of engine off.

GYROSCOPE—to give steadiness to flying machines. Intended to keep machine in upright position.

HANGAR—similar purpose as a garage. A place or shed for airplane.

LATERAL STABILITY—the stability of an airplane. To oppose lateral or side tipping.

LONGITUDINAL STABILITY—the stability of an airplane. To oppose tipping forward or backward.

LIFT—the lifting and supporting effect of the airplane wing.

MONOPLANE—an airplane with one pair of wings. The monoplane usually has great speed as the resistance to the wind is less.

PITCH—the distance the aerial screw or propeller advances when completing a revolution.

PLANE—a level surface. Usually applied to the wings of an airplane, but which are usually curved or cambered.

RUDDER—a vertical surface used for turning—see fig. 8, chart 899.

RUNNING GEAR—the wheels and its parts by which the airplane lands and runs along the ground.

SHIP—the airplane.

SIDE SLIP—see page 906.

SPIN—when through loss of flying speed ship drops nose first with a rotary motion.

STALL—a ship stalls when it loses flying speed.

STABILIZER—see page 903 and above.

SKID—a support usually placed at rear of aeroplane to absorb the shock when landing, see fig. 21A, chart 401.

SKIDDING—a term used when an airplane goes to the side further than intended when turning. Also applies to landing.

TAIL-SLIDE—see page 906.

TAIL SPIN—see chart 401.

TAKE OFF—maneuvering after leaving ground under its own power.

TAXYING—maneuver of ship on the ground under its own power.

THRUST—applies to the aerial screw or propeller to push or drive forward.

TRAILING EDGE—see fig. 9, chart 401.

VOLPLANE—see gliding.

WIND TUNNEL—a tunnel used for experimental purposes for airplanes, employing artificial air at various pressures.

Structural Parts.

Structural parts, outside of the engine or propelling machinery, consists of three parts as follows:

(1) the **fuselage** or frame work or body; (2) the **control members**, as rudder, elevator etc., (3) the **wings**.

The fuselage is usually made of light wood (spruce) material and braced with wire and then covered with sheet aluminum or fabric. The control members are shown in charts 404, 401.

Wing Construction.

The wings are made as follows: (A) is the **main or end wing rib**, fig. 25, which it will be noted is curved or cambered; other **inside ribs** are shown; B and B1, are front and rear.

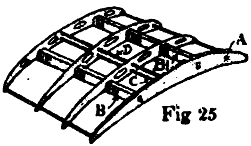


Fig 25

Spars; C and D are thin braces running through the ribs; at the front or "leading-edge," the material is wood or metal; the rear or "trailing-edge" is small steel tubing and sometimes wire.

The covering material of wing completely covers wing, above and below by being sewed and then varnished with a special varnish or "dope" to make material water-proof. The material used in most instances is linen, unbleached. Rubber proofed cloths of all kinds have been tried.

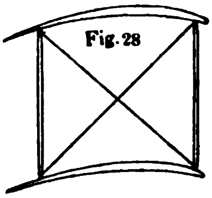


Fig. 28

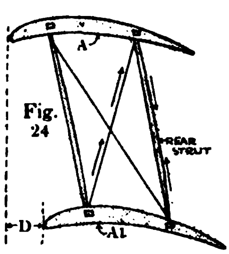


Fig. 24

The struts are the up-rights (figs. 28 and 24). They are made of various material. Spruce is used extensively which comes from California. They are cut in half-lengths, center scooped out to lighten them and glued together. Bamboo was formerly used and steel tubes are sometimes used.

The staggered strut is one placed at an angle, between main side ribs A and A1, as shown in fig. 24. This places the upper wing in advance of the lower wing as shown at (D), which is termed "stagger."

The gap is the distance between the upper and lower wing. On a "staggered" type, it can be less than when struts are vertical as shown in fig. 28.

Overhanging is a term used, when the upper wing is longer than the lower wing and projects over lower wing at each side.

Bracing Wires.

Bracing wires, or as we would term it, **guy-wires**, are necessary. There are usually cross wires in between the ribs and spars which are covered over and cannot be seen. They assist in supporting the wing frame. **The wires at end, per fig. 24, are "incidence wires."** The lift on the upper wing causes a tension as shown in arrows. The lift or push under lower wing causes a pressure against rear strut—fig. 24. **Drift wires**, fig. 27, take the resistance of the forward motion, the wires opposite are simply reinforcements, sometimes called **landing-wires**.

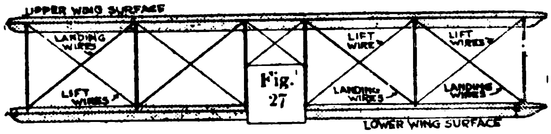


Fig. 27

The wire, generally used is silver plated piano wire of No. 26 or 28 size. Although stiff, it is not tempered. The method of fastening wire is important. Fig. 26, shows the end of wire (W) looped and fastened in a special **fastening** (E), which is connected with a turn-buckle (T), for tightening. An ordinary loop or eye will give.

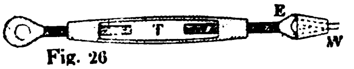
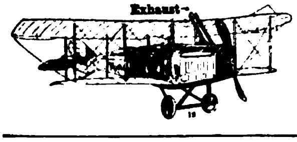


Fig. 26



The exhaust outlet of an airplane engine is usually arranged as shown at E.

A Geared-Down Propeller.

A geared-down propeller is used (fig. 15) where engine speed is higher than desired for propeller.

Note the **direct-drive** propeller, chart 407.

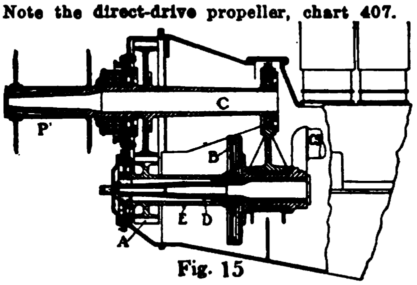


Fig. 15

P—is propeller hub; C—propeller shaft; CS—crank shaft; D—crank shaft extension; E—connects through disc (B) driving gear A, thence gear above it which is connected to propeller shaft.

Early Model Wright Biplane.

As a matter of information the illustrations are shown of this early machine. The elevator planes (V) are placed in front of machine. The one engine (M) drives two propellers (H).

Instead of ailerons the upper wing tips (fig. 23) and lower wing tips (fig. 24 below) are "warped." or flexed. This is a similar action to lowering and raising the ailerons as on other machines.

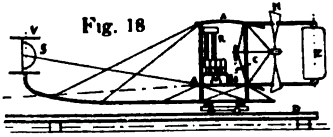


Fig. 18

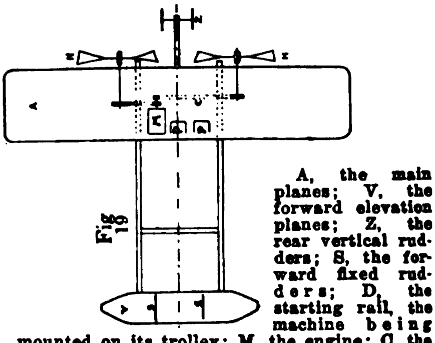


Fig 19

A, the main planes; V, the forward elevation planes; Z, the rear vertical rudders; S, the forward fixed rudders; D, the starting rail, the machine being mounted on its trolley; M, the engine; C, the driving chains; H, the propellers; P, the seats for driver and passenger; R—radiator.

For instance, turning to the left; (1) rudder is brought to left; (2) aeroplane then makes turn and its outer tip or wing rises; (3) wings are flexed so that inner tip of wing is depressed (in other words the **warping** of the wing causes the angle of incidence to increase) and rudder is put over to right; (4) inner tip then lifts and tries to slow down. but as the rudder opposes this tendency, the machine is kept on its course.

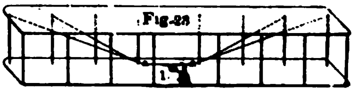


Fig-23

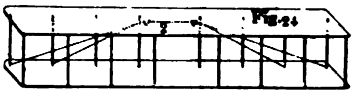


Fig-24

Fig. 23—Method of "warping" the wing tips on the early Wright biplane.

Fig. 24—Method for "warping" lower wing tips.

There are a score or more airplane engines. To deal with all would require a book in itself, therefore only typical examples will be shown.

Types of Engines.

We will classify airplane engines as "fixed type" and "revolving cylinder type."

The fixed type is where engine cylinders are stationary and are made in 4 and 6 cylinder vertical and 8 and 12 cylinder "V" type. This is the type in general use and is similar in principle to the automobile engine, especially of the racing type, which is designed for running at maximum speed for long periods of time.

The 8 and 12 cylinder "V" engines are very popular, due to the low weight per horse-power. The flywheel is practically eliminated, as the propeller takes its place.

The revolving cylinder or "rotary-cylinder" type is the Gnome, (chart 403), a French invention. This style of engine was used extensively in small, high speed, single seated machines. Another is the La Rhone.

A German machine used an engine of this type, called the Fokker, but it was copied from the French. Roland Garros was the father of it. He used a Morane-Saulenier, a small, fast, single-seater of French design, using the Gnome engine. Garros contributed to its development of adding the method of **synchronizing the time of gun shot with time of propeller,** in other words, so that he could shoot directly ahead yet not damage the propeller. This machine was captured by the Germans and improved and renamed the Fokker. These machines were soon discarded in favor of Biplanes. The rotary engine has also given way to the fixed engine of the automobile style with a multiple of cylinders, lighter and more powerful.

*Airplane Engine Ignition.

Ignition is usually by magneto. Two separate systems are usually provided, each having separate wiring and plugs.

For instance, on the Wisconsin 6 cylinder engine, chart 405, there are two 6 cylinder magnetos. Both operate at the same time, and both are connected to the same spark advance lever. Should one fail, the other will still operate engine, but with slight loss in power.

On the Wisconsin 12 cylinder engine, there are four 6 cylinder magnetos, two for each set of six cylinders. See chart 404, fig. 3, (M1-M2). On twelve cylinder engines—two 12 cylinder magnetos could and are used on some of the other makes of engines. See pages 290 to 292 and Insert for "Dixie" magneto.

On the Hall-Scott 6 cylinder engine, two 6 cylinder magnetos are used and driven as shown in chart 407.

On the Sturtevant 8 cylinder engine, chart 405, there are two 8 cylinder magnetos. Therefore it will be noted that double ignition is provided.

Spark Plugs.

There are usually, two spark plugs per cylinder and due to the fact that nearly all airplane engines have overhead valves, the plugs are placed in the side of the cylinder.

Spark plugs for airplane engine use must be of substantial construction in order that they stand the high compression—page 238.

Engine Starter.

The starting of engine by turning propeller by hand was the method formerly used, but self starters are now being placed on a great number of machines. The Christensen "gasoline and air" method, explained on page 321 being a popular system.

Fuel and Fuel System.

Fuel used, is gasoline. The Hall-Scott Co. recommend gasoline as follows; gravity 58-62 deg., Baume A. Initial boiling point (Richmond method) 102 deg. Fahr., sulphur .014. Calorimetric bomb test 20610 B. T. U. per lb. This latter part may read like Greek to the average student, but it means that the gasoline must be of a test which will produce a certain heat. For instance, a piston 10 sq. in. head surface and operating at a speed of 2000 ft. per minute would burn approximately 0.146 lb. of gasoline per minute. As one pound of gasoline contains about 19,000 British Thermal Units (the unit of heat—B. T. U.) the total heat generated per minute in the cylinder would be 2,774 B. T. U.'s at sea level.

This will give a fair idea of the thermal (heat) conditions of an engine used for airplane work operating continuously under full load. Therefore the Calometric test is a test for measuring the heat produced—which is an important factor in airplane engines. (see page 861, meaning of B. T. U.)

The fuel system used on most airplanes is the principle described on page 854, used on the Packard, by which the gasoline is forced to the carburetor by air pressure, but instead of being forced to carburetor, the gasoline tank is hung low and gasoline is fed by pressure to a small tank under upper plane, which feeds the carburetor.

Lubrication.

The force feed system is the adopted and standard method, an example of same is given on page 915. Note method of *cooling the oil.

**Compression.

The compression of airplane engines is somewhat greater than on automobile engines. As a rule the explosion pressure is four times the absolute compression pressure based on the assumption that the cylinder is filled with charge to atmospheric pressure at the beginning of the compression stroke.

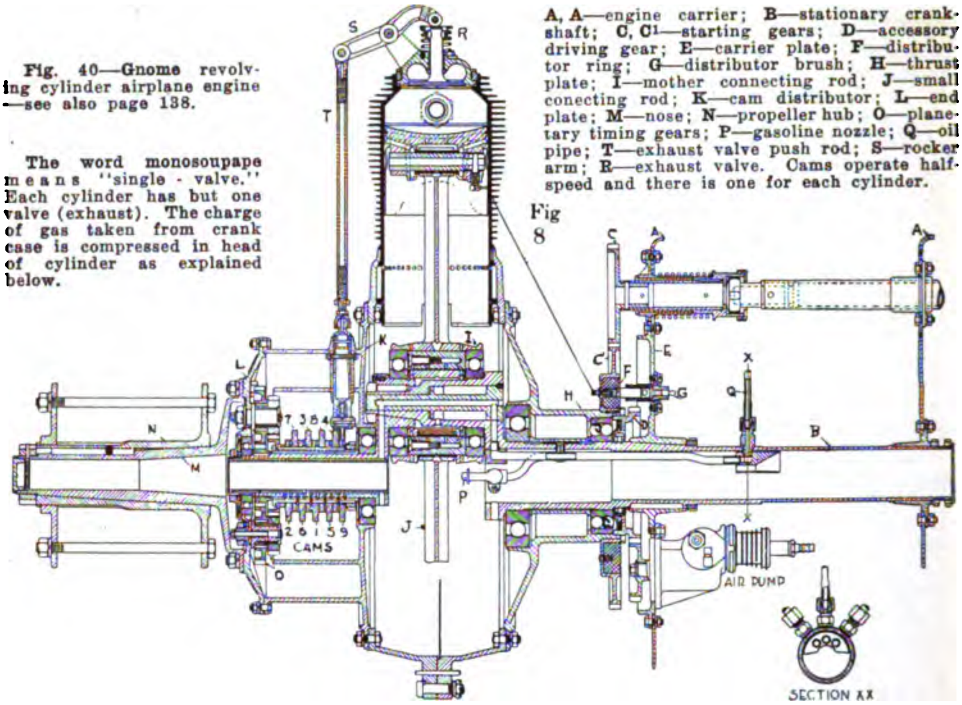
The water cooled engine with multiple of cylinders developing large horse-power with cylinders made of aluminum with steel or cast iron liners and those with steel cylinders with welded steel jackets are proving to be the successful types of airplane engines. *See also page 293—Dixie magneto.

*The reason for cooling the oil is due to the fact that an airplane engine usually runs at full power for long periods of time and considerable heat it generated. When petroleum oils are treated with air and oxygen at temperatures above 800° F., water and carbon dioxide are readily formed. The oil also loses its heavy lubricating film, so very necessary between bearing surfaces, and thins down to a point where the lubricating film is lost. Hence advantages of keeping oil at a low temperature.

**The compression on a motorcycle engine, per Insert No. 3, as a general rule is also rather high where speed is desired, but on the U. S. A. motorcycle engine, the compression is slightly lower than the average. This somewhat depresses the power curve, but engine will run better on wide open throttle at lower speed, enabling machine to "hang-on" with great tenacity and pull with power through sand, mud, etc. The U. S. A. motorcycle engine is similar to engine shown on Insert No. 3, with overhead inlet valves at 45 degrees. See also pages 793, 817, 629, 626, 640 on compression.

Fig. 40—Gnome revolving cylinder airplane engine—see also page 138.

The word monosoupape means "single - valve." Each cylinder has but one valve (exhaust). The charge of gas taken from crank case is compressed in head of cylinder as explained below.



A, A—engine carrier; B—stationary crankshaft; C, C1—starting gears; D—accessory driving gear; E—carrier plate; F—distributor ring; G—distributor brush; H—thrust plate; I—mother connecting rod; J—small conecting rod; K—cam distributor; L—end plate; M—nose; N—propeller hub; O—planetary timing gears; P—gasoline nozzle; Q—oil pipe; T—exhaust valve push rod; S—rocker arm; R—exhaust valve. Cams operate half-speed and there is one for each cylinder.

A—air pressure pipe; B—fuel pipe; N—revolving cylinders; D—pulsation gauge for oil feed; E—fuel control valve; F—fuel tube to crank case; G—air pressure gauge; H—hand air pump; J—starting handle; P—aerial screw or propeller. Castor oil used to a great extent for lubrication.

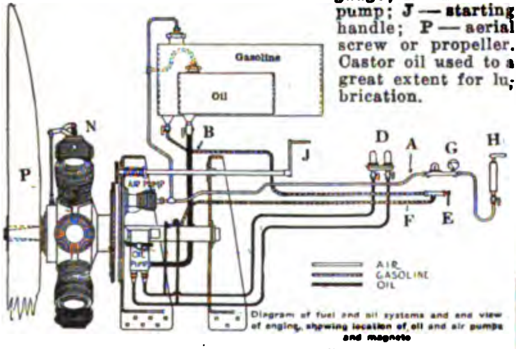
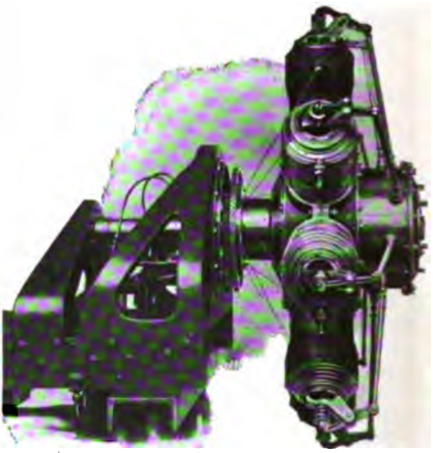


Diagram of fuel and oil systems and end view of engine, showing location of oil and air pumps and magneto

Gnome Engine Fuel System.

Fuel system. Gasoline is fed to crank case through a shut-off valve (E), through tube (F), through hollow crank shaft to a spray nozzle located in crank case. There is no throttle valve or carburetor. The gasoline in gasoline tank is under 5 lbs. pressure per sq. in. by air pump. When cylinders are within 20° of end of inlet half-revolution, a series of small inlet ports all round the circumference of wall is uncovered by top edge of the piston whereby the combustion chamber is placed in communication with the crank chamber. The crank chamber is at atmospheric pressure and combustion chamber is below atmospheric. result is, a suction is created which draws gas from the crank chamber to combustion chamber. The air for mixture is provided by admission through exhaust valve during first part of the inlet stroke. Originally an inlet valve was located in center of piston head—this is not now used.



Side view, mounted for testing. **Model** B-2; H. P.—100; cylinders, 9; bore, 110x150 mm.; weight with ignition 272 lbs.; gasoline consumption per hour, 12 gal.; oil consumption, 2.4.

Gnome Ignition.

One high tension Splitdorf magneto is provided, located in the thrust plate in an inverted position and driven at a speed to produce 9 sparks (9 cyl. engine), for every two revolutions—that is, at 2¼ times engine speed. A distributor is shown in top illustration, mounted separate at (F & G).

—continued on next page.

CHART NO. 408—The Gnome Monosoupape Revolving Cylinder Engine—made by The General Vehicle Co., Long Island City, N. Y.

(From Automobile and Automotive Industries and Motor Age.)

Gnome Ignition—continued.

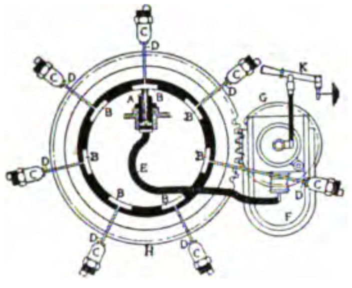


Fig. 10—Wiring of ignition system used on Gnome engine

In the Gnome seven-cylinder engine there are three and a half explosions per revolution, or seven every two revolutions. The firing order is 1-3-5-7-2-4-6.

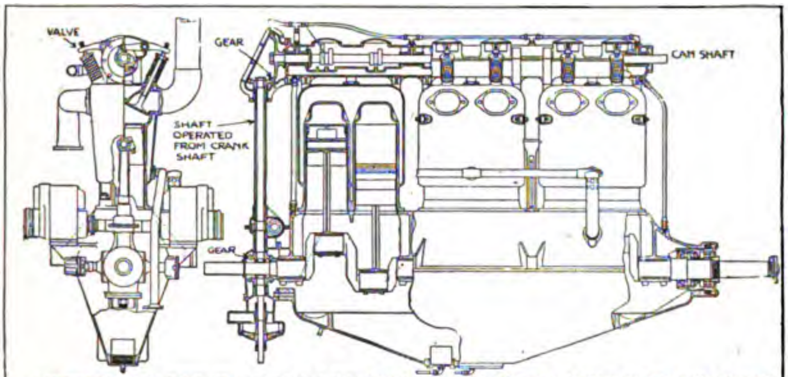
In the fourteen-cylinder engine the firing order is the same, with one set of cylinders alternating with the other and giving twice as many explosions per revolution.

The wiring of the ignition system is shown in fig. 10. It will be noted that the brush A makes contact with the metallic sectors B as they pass. Each sector is connected with its corresponding spark plug C through wire D. As the sector passes over the brush a spark is produced in that cylinder and the charge fired. The high-tension cable E connects the high tension terminal of the magneto F to the brush. On the earlier forms of the Gnome engine the magneto remains stationary and in an inverted position. The gear G is keyed to the magneto shaft and engages with the large gear H which turns the cylinders.

The Wisconsin Airplane Engine.

Six cylinder engine; bore 5 in., stroke 6½ in., weight 600 lbs.; h. p. 130 at 1200 r. p. m., and 145 h. p. at 1400 r. p. m.

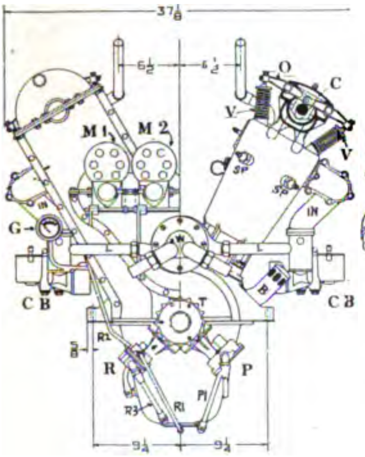
Oiling system, force feed through crank shaft. Oiling system arranged so that it will feed when climbing at an incline of 15°, and 30° when gliding.



Wisconsin six-cylinder aviation engine which has a valve action quite similar to that used on the Stutz racing cars. The camshaft is carried overhead

Valves are 3 in., placed in head at 25° angle and operated by an overhead cam shaft. Exhaust closes 10° late; inlet opens 10° late; exhaust opens 55° early and inlet closes 55° after bottom. **Cylinders cast in pairs.**

Water circulation, 6 cylinder; one centrifugal pump (W); on the 12 cylinder there are two pumps.



TWELVE CYLINDER—END ELEVATION.

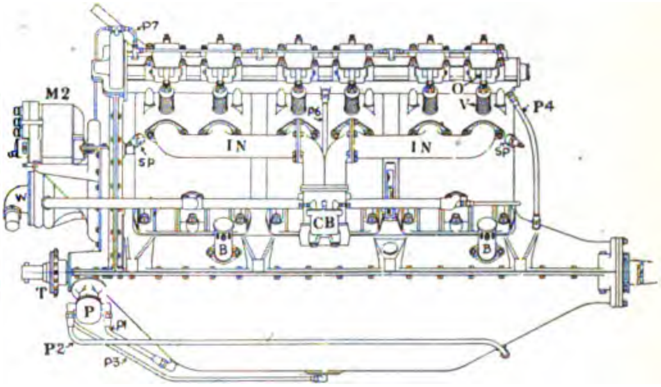


Fig. 3—Wisconsin 12 cylinder "V" type engine. M1-M2 — magnetos; V—valves; O—arm operating valves; C—cam operating arms and of overhead type; CB—carburetors; IN—inlet manifolds; SP—spark plugs; B—breather; G—oil gauge; R—double oil pump. There are three oil pumps on the 12. Exhaust outlet is directly below the letter (V) above.

The cam shafts and magnetos on the 12, are driven by a train of ball bearing spur gears from the crank shaft. **Double valve springs** are also employed—the inner spring acting as a safety to prevent valve falling into cylinder should main valve spring break. **Ignition**, see page 909.

Carburetion; one carburetor (CB) is used on the 6 cylinder engine and two on the 12 cylinder engine.

Specifications of 12 cylinder engine; bore, 5 inch; stroke 6½ inch; weight 1000 lbs.; h. p. at 1250 r. p. m. 250; h. p. at 1400 r. p. m. 280.

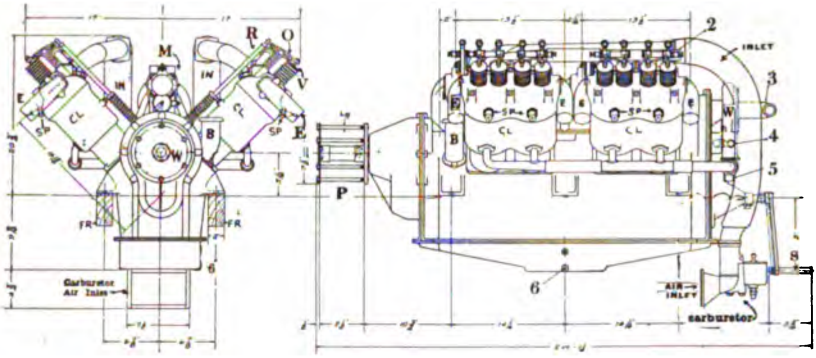
T—sprocket for starting chain; P—single oil pump; P1 from oil reservoir to pump; P4 and P6—overflow from cam shaft housing.

CHART NO. 404—Gnome Engine Ignition. Wisconsin Six and Twelve Cylinder Airplane Engin

The Sturtevant Eight Cylinder Airplane Engine.

Illustration is that of the Sturtevant 8 Cylinder V-type engine. It is made in 140 h. p. with 4 in. bore x 5½ in. stroke and 4½ in. bore with 5½ in. stroke developing 210 h. p. The normal speed is 2250 r. p. m. of crank shaft.

Valves are in head and operated by push rods; **cylinders** are cast in pairs; **pistons** aluminum alloy; **rings**, there are two to each piston; **crank shaft**, nickel steel 2¼ in. di.



Parts of Sturtevant 8-cyl. engine; M—magneto; IN—inlet manifold; CL—cylinders; SP—spark plugs; W—water pump; B—breather; E—exhaust; FR—support to which engine is attached; B—push rod; O—rocker arm operating valve V; 6—oil outlet, auxiliary tank; 5—where tachometer shaft connects; 4—inlet to oil supply pipe; 3—double water inlet; 2—water outlet 1¼ in.; S—starting crank.

Carburetion Zenith "duplex" shown on page 182.

The inlet pipes (IN) are water jacketed. The fuel is fed by gravity.

Circulating pump (P) is shown between inlet pipes.

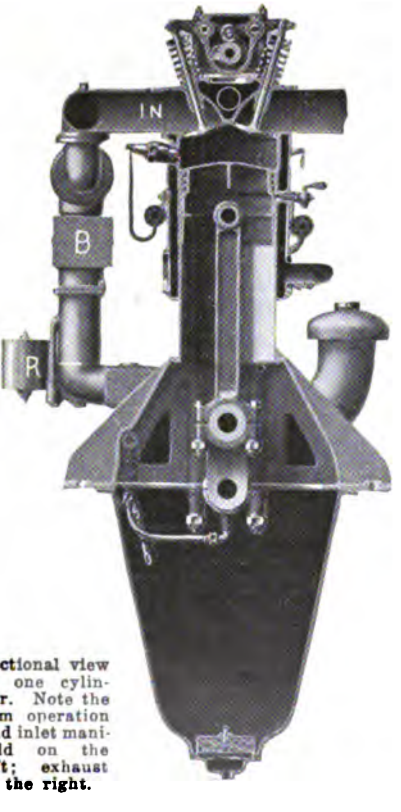
Engine lubrication by force feed.

Ignition by two 8 cylinder magnetos; **spark plugs**—two to each cylinder mounted inside of cylinders in water cooled bosses.

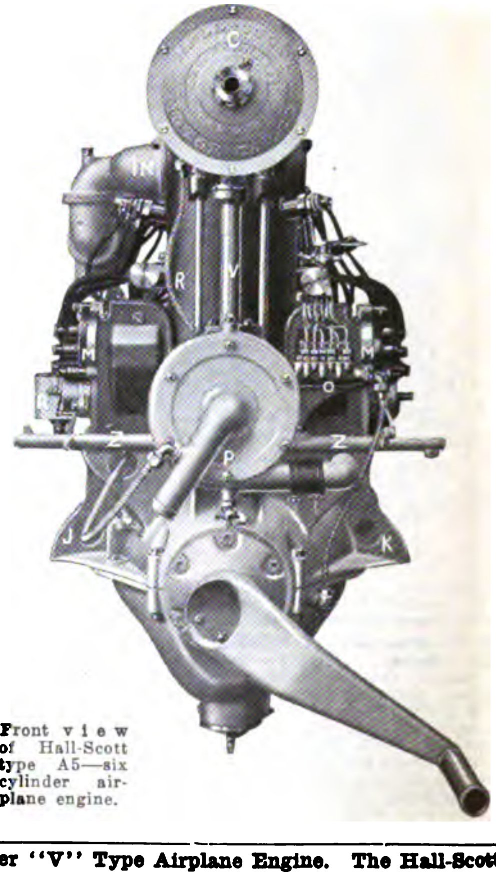
The Hall-Scott Airplane Engine

is described on pages 913 to 915. Two views are shown below of the type A-5—six cylinder engine. The four cylinder engine, type A7 and A7a are similar in construction.

Name of parts lettered: B—oil jacket circulating oil around inlet manifold to cool it; R—pipe for draining oil from cam-shaft housing back to crank case; J—water pipe from pump to inlet manifold (see page 914); K—pipe from auxiliary oiler (O) to crank case, for cylinder lubrication; M—magnetos; Z—spark advance lever rod; C—cam shaft housing cover; R—carburetor; IN—inlet pipe; V—vertical drive shaft housing.



Sectional view of one cylinder. Note the cam operation and inlet manifold on the left; exhaust to the right.



Front view of Hall-Scott type A5—six cylinder airplane engine.

HART NO. 405—The Sturtevant Eight Cylinder "V" Type Airplane Engine. The Hall-Scott Six ylinder Airplane Engine—see also pages 913, 914, 915.

The Hall-Scott Airplane Engines.

Are made in four types as follows: type **A-7**, 90 h. p., 4 cylinder; type **A-7a**, 100 h. p., 4 cylinder; type **A-5**, 125 h. p., 6 cylinder; type **A-5a**, 150 h. p., 6 cylinder. This h. p. is developed at 1300 r. p. m.

Cylinders are cast separate and made from a mixture of grey and Swedish iron. Inner walls of cylinders and valve seats are hardened and ground.

Valves.

Valves are overhead operated by an overhead cam-shaft.

Valves are placed in head of cylinders at a slight angle. The valves are operated by an overhead cam shaft enclosed in a housing (see page 914). The valves are one-half the diameter of the cylinder bore and are made of Tungsten steel.

The type A-5, 6 cylinder engine has a bore of 5 in. and 7 in. stroke. Weight of type A-5 complete, is 565 lbs.

Cam Shaft.

Cam shaft is made of chrome nickel forging and the four cam shaft bearings are made from Parson's white brass. A small clutch is milled in rear end of shaft to drive the revolution indicator (tachometer). **Cam shaft** is enclosed in an aluminum housing and driven by a vertical shaft with bevel gears. Oil is forced through end of this shaft permitting surplus supply to flow back to crank case.

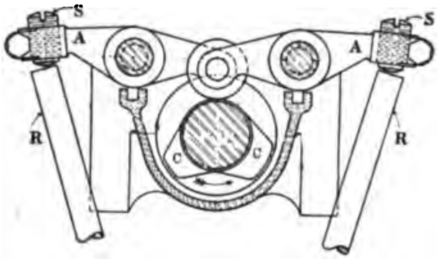


Fig. 1—Setting of adjustable set screw (S) in rocker arm (A) in relation to the valve stem (R). In other words the method of setting valve-clearance on all types of Hall-Scott engines. The clearance should be .020" when valves are seated.

Valve and Ignition Timing.

Valve timing on type A-7 and A-5 engine is as follows; exhaust closes 15° late; inlet opens 10° late; exhaust opens 45° early; inlet closes 40° after bottom. **Magneto** is set to fire 27° before top of compression stroke—advanced. **Firing order:** 4 cyl. engine, 1, 2, 4, 3; 6 cyl., 1, 5, 3, 6, 2, 4.

Valve timing in type A-5a and A-7a engines: exhaust closes 10° late; inlet opens 15° late; exhaust opens 54° early; inlet closes 45° after bottom. **Magneto** setting same as A-7 and A-5.

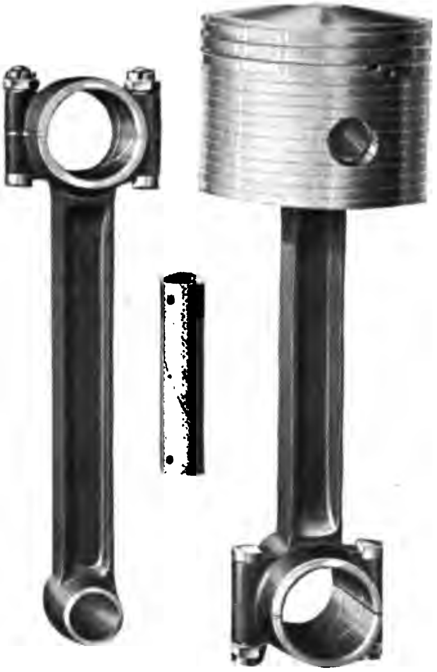
Curtiss OX2 valve timing: Ex. opens 50° before bottom; Ex. closes 10° after top; inlet opens 14° after top; inlet closes 48° after bottom. Average valve stem and rocker arm clearance .010".

Grinding Valves.

To grind the valve seats, place a bar, having two holes through same, down over the two cam shaft housing hold-down studs opposite the valve to be removed. Replace the two nuts. Remove the cotter pin in valve stem under the valve spring cup. Using a special Hall-Scott valve tool which can be slipped under the bar, it will be easy to force the valve cup and spring down so the small key can be readily removed. This will allow the removal of both valve spring and cup. Take out the valve and clean it thoroughly, also noting whether or not the stem is clean, or otherwise in good condition. Replace the valve and grind by rotating it back and forth with a screw driver, the grinding paste being between the valve and the seat. Care should be taken to raise the valve from its seat frequently while grinding. This prevents grinding a groove in the seat.

Connecting Rod.

The connecting rods are I-beam type very light. Piston end is fitted with gun metal bushing while crank pin end carries two bronze serrated sleeves tinned and babbitted hot. Laminated shims are placed between cap and rod for adjustment.



Pistons.

Pistons are aluminum alloy. Note piston pin is placed very low in order to keep heat from piston head and away from upper end of connecting rod, as well as to arrange them at the point where piston fits cylinder best.

The Magnalite piston is used to a great extent. Piston rings are ¼ inch wide. There are 8 to a piston.

Oiling System

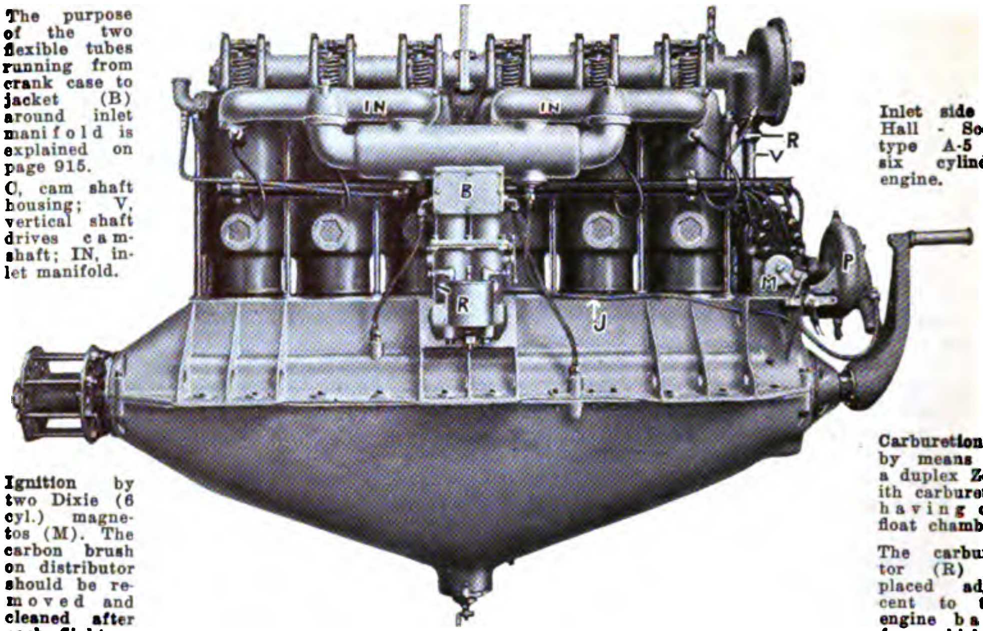
Oiling system is known as the high pressure or force system. A gear pump is located in the inside lower portion of the oil sump—see page 915.

Gasoline System.

Air pump is power driven and maintains pressure in the gasoline tank and is a similar system to Packard, page 854. A hand pump is also provided so that pressure can be obtained before engine starts.

The purpose of the two flexible tubes running from crank case to jacket (B) around inlet manifold is explained on page 915.

C, cam shaft housing; V, vertical shaft drives cam-shaft; IN, inlet manifold.



Inlet side of Hall - Scott type A-5 — six cylinder engine.

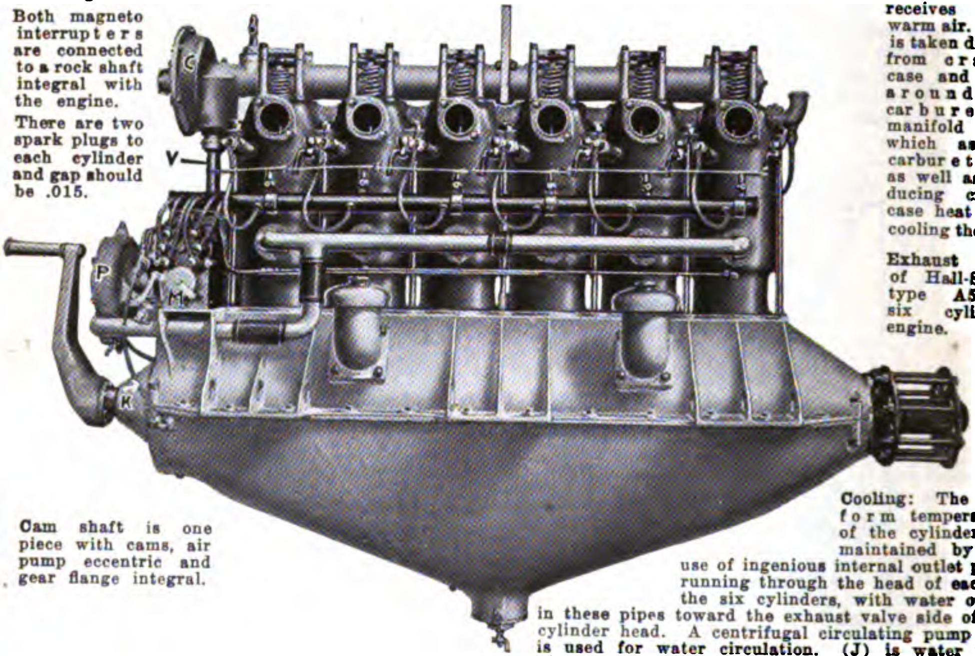
Ignition by two Dixie (6 cyl.) magnetos (M). The carbon brush on distributor should be removed and **cleaned after each flight.**

Both magneto interrupters are connected to a rock shaft integral with the engine.

There are two spark plugs to each cylinder and gap should be .015.

Carburetion is by means of a duplex Zenith carburetor having one float chamber.

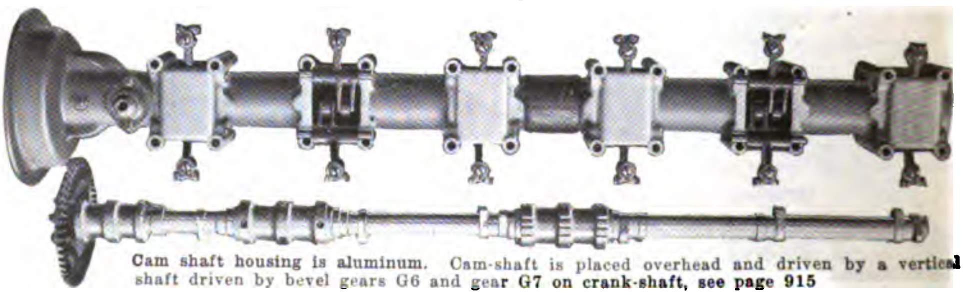
The carburetor (R) is placed adjacent to the engine base from which it receives its warm air. Oil is taken direct from crank case and run around the carburetor manifold (B), which assists carburetion as well as reducing crank case heat and cooling the oil.



Exhaust side of Hall-Scott type A5 — six cylinder engine.

Cam shaft is one piece with cams, air pump eccentric and gear flange integral.

Cooling: The uniform temperature of the cylinders is maintained by the use of ingenious internal outlet pipes running through the head of each of the six cylinders, with water outlet in these pipes toward the exhaust valve side of the cylinder head. A centrifugal circulating pump (P) is used for water circulation. (J) is water inlet pipe to intake manifold.



Cam shaft housing is aluminum. Cam-shaft is placed overhead and driven by a vertical shaft driven by bevel gears G6 and gear G7 on crank-shaft, see page 915

CHART NO. 406—Hall-Scott Six Cylinder Airplane Engine—continued.

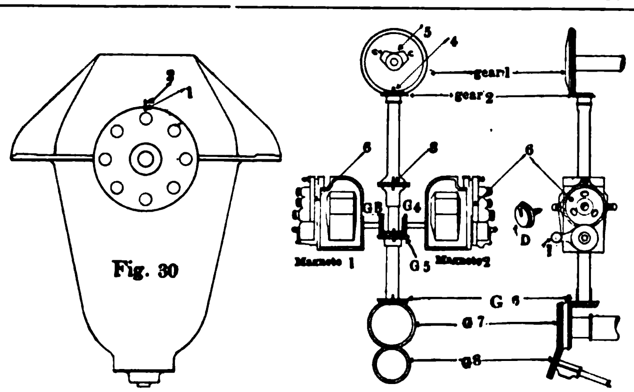


Fig. 30

DIAGRAM OF MAGNETO AND CAM SHAFT DRIVING GEARS IN HALL-SCOTT. TYPE A-5. 125 H. P. ENGINE.

Magneto and Cam-Shaft Driving Gears—Hall-Scott.

5—shows position of no. 1 cylinder cams when no. 1 piston is on top of dead center of compression stroke. When timing, the mark (1) on crank shaft flange (fig. 30), is brought true with mark (2) on crank case. It is stamped "T. C. 1-6," meaning, 1 & 6 cylinders are on dead center. A mark (8) is provided on vertical shaft flanges. These must be set in dead center position as shown. The cam shaft with housing is now slipped into place. Note mark (4) on cam shaft gear—this should line up with mark on bottom of cam shaft gear housing.*

Magneto installation, after assembly as above, take magneto marked (L) at base (meaning left hand), remove distributor, turn magneto shaft until hole with red ring, lines up with red mark on magneto body. Insert magneto left hand and magneto right hand. After gears are meshed, be sure holes on gears are directly in line with red marks in magneto body. Both magneto breaker points should synchronize or break at same time.

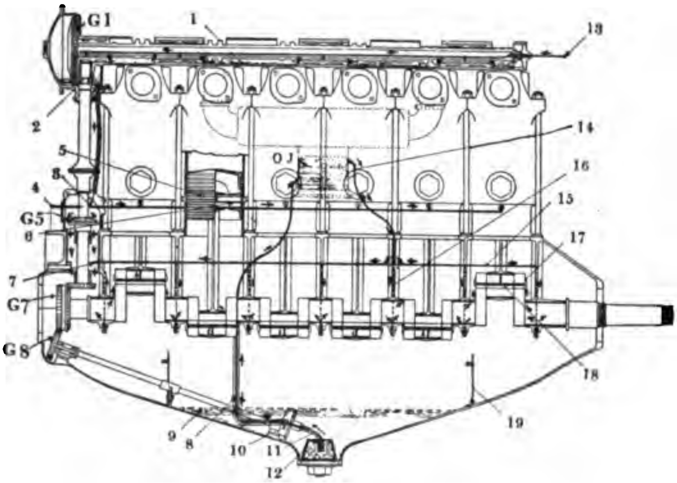


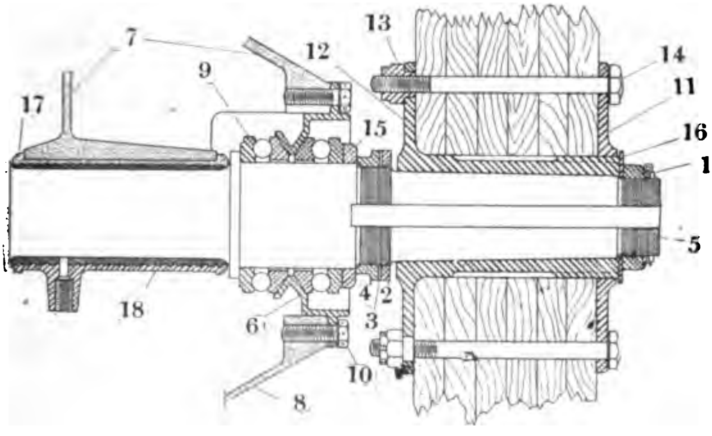
Diagram of Hall-Scott type A-5 engine oiling system. Heavy dotted lines and arrows show direction of oil flow. Note the method of cooling the oil—see 8 and 14.

Oil is first thrown from strainer (12) by pump, to long jacket (OJ) around inlet manifold, thence forced with a pressure of from 5 to 80 lbs. to distributor pipe (15) in crank case. An independent oiling system using a small direct drive rotary oiler, feeds oil to each individual cylinder.

The oil is cooled by circulating it around the long inlet manifold jacket in such a manner that the carburetion of gasoline cools it.

Oiling Diagram.

1—excess oil from bearings flows into reservoirs between; 2—oil overflows into overflow pipe; 3—oil comes out of overflow pipe and after oiling gears, excess oil flows down through magneto gear housing into sump; 4—individual oil pipe from distributor to each cylinder, automatically injects oil onto pistons as each one passes oil port; 5—oil rings on piston, oil circulates into hollow wrist pin, oiling upper end of connecting rod; 6 — section through piston, showing hollow wrist pin;7—relief valve and by-pass at end of main oil pipe, through which excess oil flows back into sump; 8 — oil is pumped through pipe to cooling reservoir on gas intake manifold; 9—reservoir of oil in sump; 10—oil pump; 11—oil suction to pump; 12—oil strainer and clean out plug; 13—oil comes from auxiliary hand pump into hollow camshaft; 14—oil flows from cooling reservoirs down into main oil pipe; 15—main oil pipe; 16—individual leads to bottom of each main bearing cap; 17—excess oil from bearings drips into scuppers on crank cheeks; 18—hollow crank pin, which oils connecting rod bearing; 19—baffle plates.



Propeller Bearing.

Details of propeller double thrust bearing used on the Hall-Scott engines. For thrust or tractor type propellers.

1—nut in crank shaft; 2—nut on thrust lock; 3—washer; 4—nut on inner thrust; 5—crank shaft; 6—collar thrust; 7 — upper crank case; 8—lower crank case; 9 — thrust bearing; 10—screw for thrust collar; 11—propeller flange; 12—crank shaft flange; 13—propeller bolt nut; 14—propeller bolt; 15—spacer for thrust bearing; 16—washer for crank shaft nut; 17-18 —rear bushing for rear bearing of engine crank shaft.

CHART NO. 407—Details of Hall-Scott Engine. Propeller Bearing.

See page 295 for speed of cam-shaft and magneto of a six cylinder engine. When crank-shaft turns once; m neto armature turns 1½ rev.; distributor on magneto ½ rev.; cam-shaft ½ rev.

*The gear clearance is .020" except gear G7 & G6 which is .010"; bearing clearance is .001" and spark plug gap .015

Mercedes Engine.

Two Mercedes engines of 260 h. p. each are used on the Gotha airplane. These are of the six-cylinder vertical tandem type with the cylinders made singly and their waterjackets connected together by joints. There is a slightly greater distance between cylinders Nos. 3 and 4 than between the other cylinders.

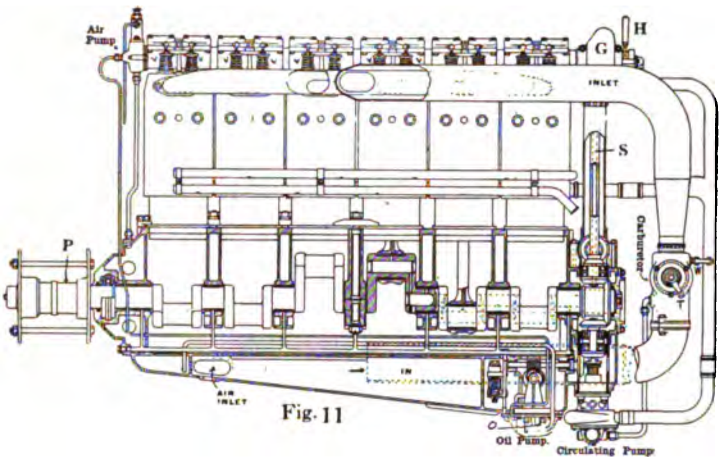


Fig. 11

Cylinders; the waterjacket of each cylinder is connected by a joint to the jacket of the adjacent cylinder, and each cylinder is separately secured to the crankcase.

Cylinder bore, 160 mm. (6.3 in.), **stroke**, 180 mm. (7.09 in.), and the engine develops from 258 to 260 h. p. at 1400 r. p. m.

Cylinders are of the "built-up" type (fig. 13), composed of steel, machined. Sheet steel is pressed to form water jacket and is acetylene welded.

Cylinder barrels are screwed into cylinder head at (T). They are machined from forgings and cylinder walls taper from 3.5 mm. at top to 6 mm. at bore or flange.

Stiffening ribs (C) are aranged as shown.

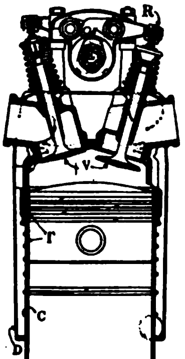


Fig. 13

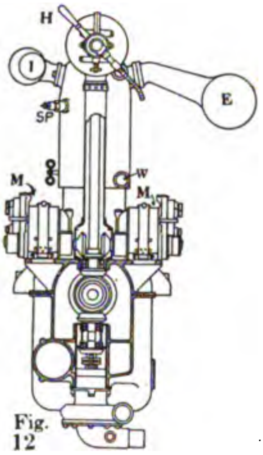


Fig. 12

Cylinder heads are machined from steel forgings, and into these are built 4 valve pockets, also inlet and exhaust ports. **Seatings for valves** are machined in the cylinder heads. **Valve pockets** are machined from steel and are acetylene welded into heads. **Exhaust valve guide** has a greater water space than inlet.

The hourly consumption is equal to 76 liters (20 gal. of gasoline) and five liters (1.32 gal.) of oil.

A single carburetor is installed, instead of the dual or two combined carburetors on the 170 h. p. engine and the two separate carburetors on the 235 h. p. The carburetor is located at the forward end of the engine and draws its air through the crankcase, through "air inlet," thence through "in," which tends to heat the mixture and to keep the crankcase cool. A single inlet pipe of enormous size extends from the carburetor. **Carburetor is water jacketed at (W).**

Ignition is by two Bosch ZH6 magnetos (M), connected to the camshaft (fig. 12) which latter extends horizontally across the tops of the cylinders.

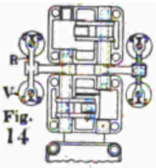


Fig. 14

Spark plugs—there are two, to each cylinder (SP).

Valves; there are four valves in each cylinder—see figs. 13 and 14. The two exhaust valves are on one side and two inlets on opposite side.

When starting—a compression relief mechanism with a hand lever (H, figs. 11 and 12) is moved to the side, which displaces the camshaft by throwing into play, small cams located opposite the exhaust cams, which keep the exhaust valves open during part of compression stroke, thus reducing the compression.

Cooling is by water. The water pump driving spindle is lubricated while in flight by means of a ratchet-driven grease gun or pump, worked by a cable and lever from the pilot's seat.

An electrical tachometer is driven at engine speed from the rear end of the camshaft, through a flexible shaft.

Fuel—an air pump is driven from front end of cam shaft, for providing air pressure to gasoline fuel tank.

Oiling system: forced lubrication is, of course, employed. A four-throw eccentric-driven plunger pump is fitted. An "auxiliary" sump in the front end of the crank case is embodied, and small supplementary pump plungers, which work in conjunction with the main oil pump, feed fresh oil into the system from the service oil tank, which is connected to oil pump at (O), fig. 11.

CHART NO. 408—The Mercedes 260 H. P. Airplane Engine as used on the Gotha Biplane, fig. 3, chart 399. (Automobile and Automotive Industries.)

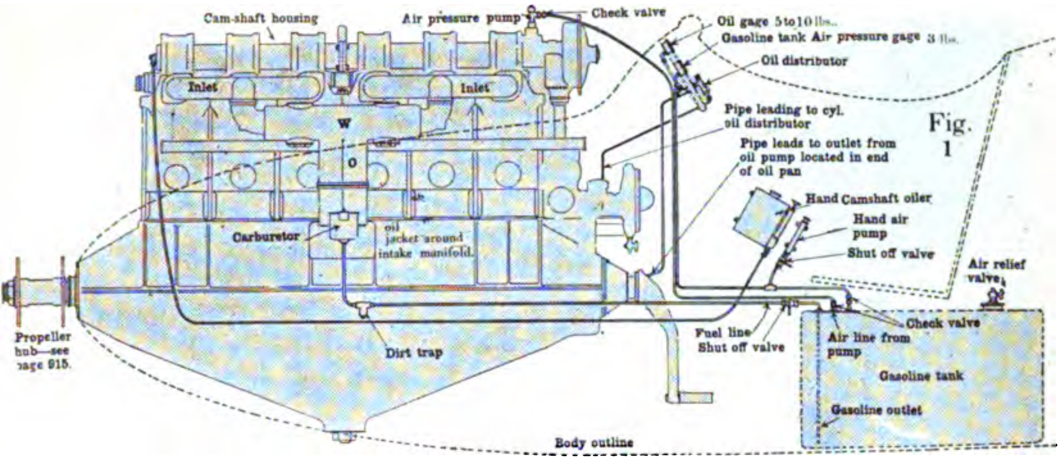


Fig 1. Illustration showing the engine installation of the Hall-Scott, type A-5, 125 h. p. six cylinder engine. Also the gasoline system and auxiliary cam shaft oiling system. Note gasoline air pressure pump is operated by cam shaft. There is also an auxiliary hand air pump. The air pressure (not under 3 lbs) forces the gasoline through gasoline outlet pipe to carburetor. On some systems another small auxiliary tank is provided above carburetor, about 2 feet, to which the gasoline is forced by air pressure and then the gasoline is fed to carburetor by gravity. Note the auxiliary hand lubricator for cam-shaft. A water jacket (W) surrounds the inlet manifold to heat the mixture per page 157. The lubricating oil circulates around inlet pipe in jacket (OJ), see page 915.

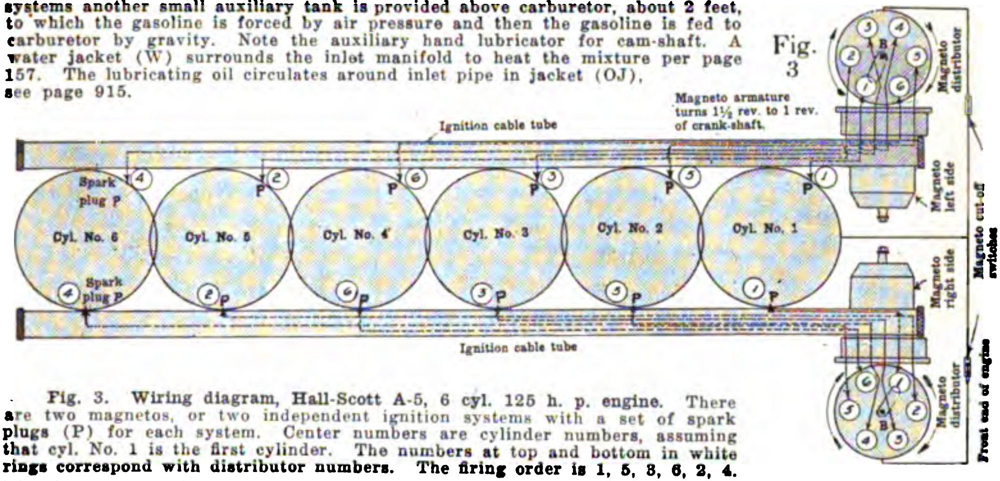
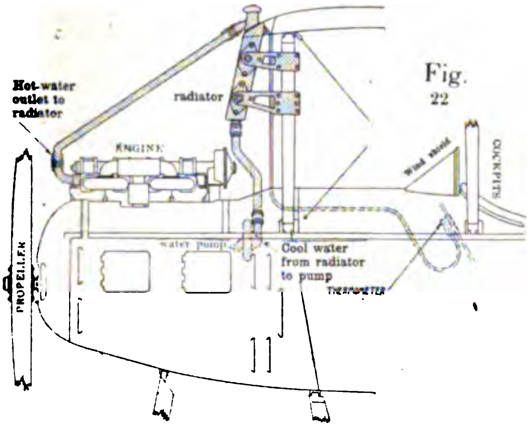
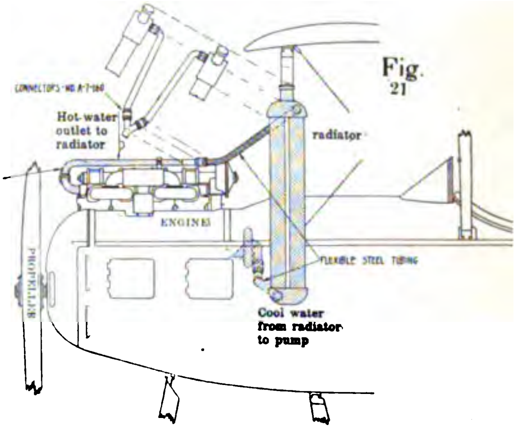


Fig. 3. Wiring diagram, Hall-Scott A-5, 6 cyl. 125 h. p. engine. There are two magnetos, or two independent ignition systems with a set of spark plugs (P) for each system. Center numbers are cylinder numbers, assuming that cyl. No. 1 is the first cylinder. The numbers at top and bottom in white rings correspond with distributor numbers. The firing order is 1, 5, 3, 6, 2, 4. Distributor brush (B) is on cyl. No. 1, the next to fire will be cyl. No. 5 (distributor connection No. 2), and etc. Both systems can be used or each separately by operation of magneto switches.



FRONT. OVERHEAD. RADIATOR INSTALLATION.
Used in connection with Hall-Scott. Type A-7a, 100 H. P. Airplane Engine.

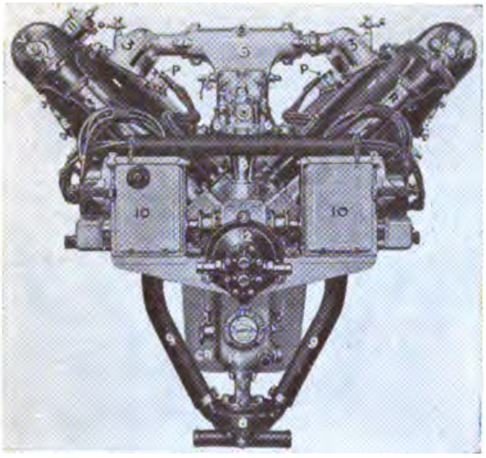
Fig. 22: Illustrates how a single radiator is installed in the front, overhead and water connection thereto. Note the thermometer is the distance or extension type "Motor meter" described on page 921.



SIDE RADIATOR INSTALLATION.
Used in connection with Hall-Scott, Type A-7a, 100 H. P. Airplane Engine.

Fig. 21: Illustrates how two radiators are installed, one on each side of engine. These illustrations are Hall-Scott type A-7a, 100 h. p. four cylinder engine.

CHART NO. 409—Gasoline System; Ignition, Firing Order and Radiator Installation on Hall-Scott Airplanes.



Hispano Suiza Engine.

Model E, 180 h. p. V-type 8 cylinders. Two sets of spark plugs. Two magnetos are carried at front end. Valves are actuated from cams by an overhead cam shaft on each cylinder block and the carburetor is hung centrally. Bore is 120 m. m. and 130 m. m. stroke (approximately 4¾x5⅛). Weight is approximately 450 pounds including magnetos, carburetor, but without radiator or exhaust pipes. Speed 1,450 r. p. m. Pistons aluminum alloy. Connecting rods forked. Crank shaft has 5 bearings. Illustration shows the rear view of engine.

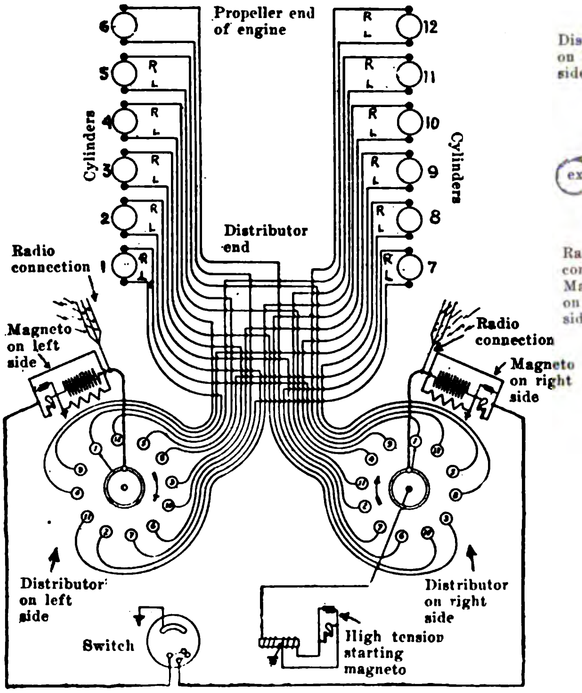
Name of Parts.

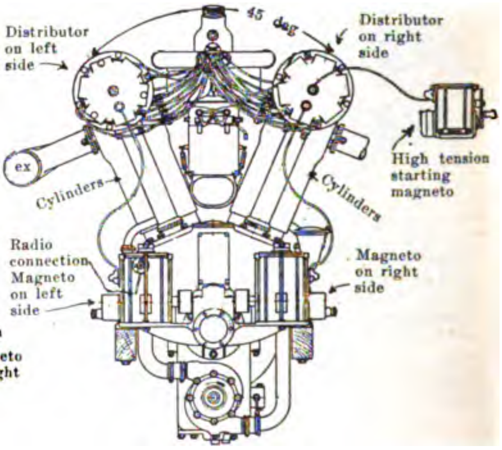
1, cylinders; 3, inlet manifold; 5, part of inlet manifold with hot water jacket; 6, carburetor duplex type; 8, water pump; 9, water pipes; 10, magnetos; 12, oil circulating pump; V, overhead cam shaft housing; E, exhaust; B, breather pipe to crank case; P, spark plugs; R, housing for shaft driving overhead cam-shaft; CR, crank case, lower part; **Cylinders** are set at an angle of 90 degrees.

Wiring Diagram of a Twelve Cylinder V-Type Airplane Engine Using Separate Distributors, Two Magnetos and Showing Radio Connections.

On airplane engines of the 12 cylinder V-type with cylinders set at 45° angle between the two rows of cylinders, magnetos of the high-tension type are sometimes used, with distributors driven separately and employing a separate high-tension magneto for starting—see illustrations below and page 922.

The magnetos operate 1½ times engine crank-shaft speed. The distributors revolve 1 rev. to 2 of engine crank. The distributor segments are spaced 37½° and 22½° apart, alternately. For automobile work this would cause an uneven impulse at very low speeds, but for airplane work where engine is running at full speed, it is not noticeable. The advantage for airplane work is to use a smaller hood and reduce head-resistance. If distributor revolves ½ speed of engine crank-shaft, then firing relative to crank would be 75° and 45°. Magneto armature produces current at 67½ and 112½ degrees—a sparking range of several degrees permits this. Magneto produces 4 sparks per revolution.





Two magnetos are here used, each producing a spark in each cylinder at the same time. A separate high tension geared up magneto for starting by hand cranking is an auxilliary source. A trailing pin in distributor is set later than main distributor brush.

The magnetos are commonly set on the engine so that the spark occurs from 23 to 28° ahead or in advance of dead center position of piston.

Referring to meaning of R and L above, note R cable from spark plugs connect with distributor on the right and L cables with distributor on the left.

Firing order of above twelve cylinder engine is 1, 12, 5, 8, 3, 10, 6, 7, 2, 11, 4, 9—refer to numbers to the side of cylinders.

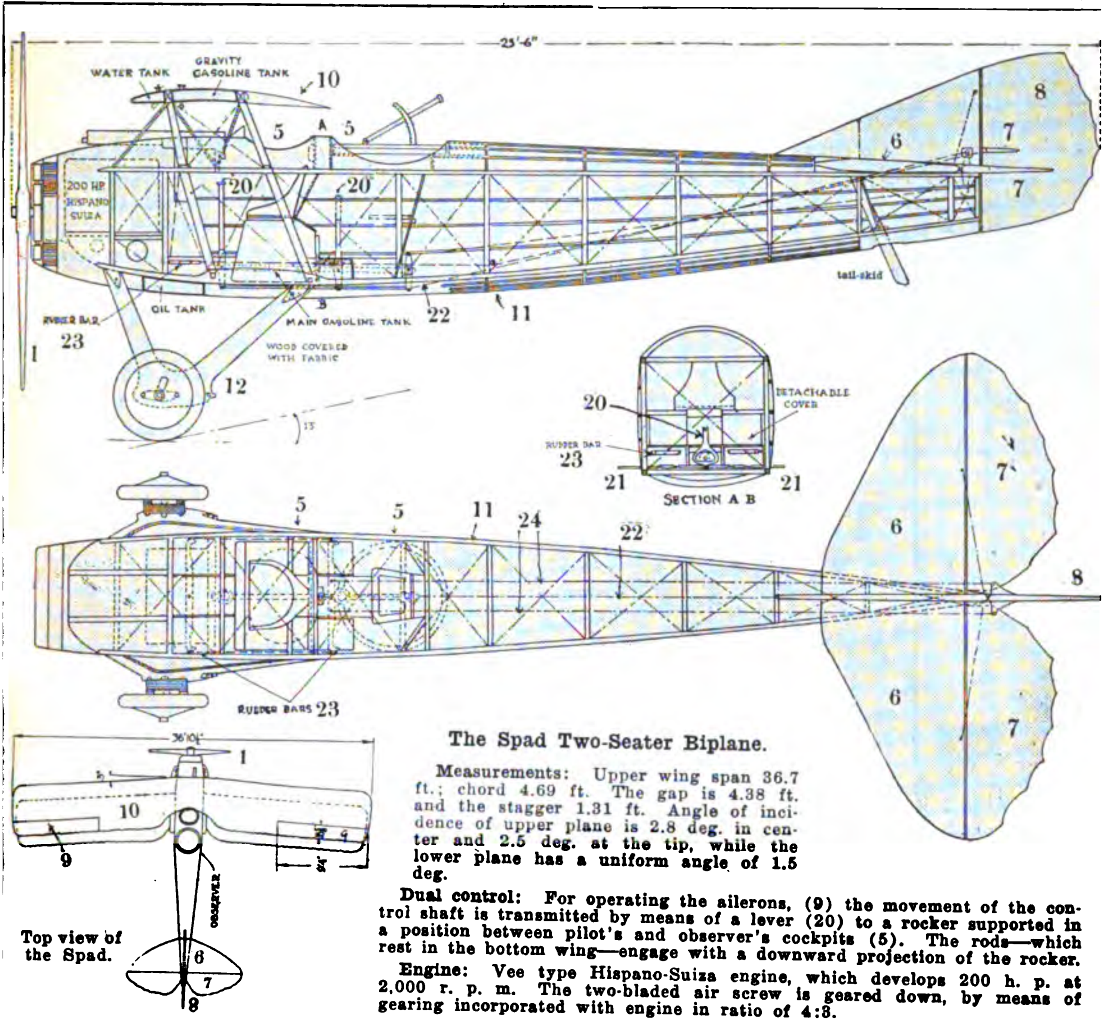
Firing orders 8 cyl. airplane engines; Sturtevant, 4L, 1R, 2L, 3R, 1L, 4R, 3L, 2R (see diagram fig. 2, page 131); Hispano-Suiza, 4L, 1R, 3L, 2R, 1L, 4R, 2L, 3R; Curtiss OX2, 4L, 4R, 3L, 3R, 1L, 1R, 2L, 2R.

Castor oil is considered an ideal lubricant for airplanes of both the revolving and stationary cylinder type, for the following reasons as stated by The Baker Castor Oil Co., N. Y.: higher viscosity, lower heat conductivity, no carbon, higher fire test, higher flash test, lower cold test and will not mix with mineral oil.

CHART NO. 410—Hispano Suiza Airplane Engine. Wiring Diagram 12 Cylinder V-Type Airplane Engine. Firing Order 8 Cyl. Engines. Castor Oil.

***Note the 12 cylinder engine page 135, has cylinders 60° angle.** (Two lower illustrations courtesy **Motor Age.**)

The above wiring method is the same as used on the Liberty Engine, except Delco coil and battery, distributor and timer ignition system is used instead of magnetos—see pages 938 and 939.



The Spad Two-Seater Biplane.

Measurements: Upper wing span 36.7 ft.; chord 4.69 ft. The gap is 4.38 ft. and the stagger 1.31 ft. Angle of incidence of upper plane is 2.8 deg. in center and 2.5 deg. at the tip, while the lower plane has a uniform angle of 1.5 deg.

Top view of the Spad.

Dual control: For operating the ailerons, (9) the movement of the control shaft is transmitted by means of a lever (20) to a rocker supported in a position between pilot's and observer's cockpits (5). The rods—which rest in the bottom wing—engage with a downward projection of the rocker.

Engine: Vee type Hispano-Suiza engine, which develops 200 h. p. at 2,000 r. p. m. The two-bladed air screw is geared down, by means of gearing incorporated with engine in ratio of 4:3.

Fuel: A main fuel tank with pressure system has a capacity of 37 gal. and forms the pilots seat, while a gravity tank holding 2.65 gal. is mounted in the upper wing, between the spars. The fuel capacity is sufficient for two hours flight. **Oil tank** holds 4 gal. and rests on floor of body behind engine. Bottom of oil tank has pressed on ribs for cooling the oil. **Radiator** is provided with shutters and forms nose of fuselage. **Instruments**; on the right, the starter and hand operated air pump. In center; two switches, one three-way cock for pressure tank and connecting with either hand or engine air pump, one three-way cock handle for turning on or off gasoline from tank to carburetor, one tap for turning engine air pump off pressure tank, one manometer (water circulating gage) and revolution indicator. On the left: the gas lever, lever for regulating the mixture, and lever for operating radiator shutters. No provision is made for advancing or retarding the magneto. Weight of machine empty, but including the cooling water 1680 lbs. **Item weights**; engine 480 lbs.; cooling water 69.6 lbs.; wings 370.0; elevator and rudder 43.8; body etc., 710.0; total 1673.4 lbs. **Loading**; pilot and observer 374.0 lbs.; armament 179.0; instruments, etc. 7.7; fuel 264.0 or total 824.7.

Types of Airplanes.

Are divided into types as follows:

Combat machines; small fast single-seaters. Wing spread of from 20 to 25 ft., speed 125 to 135 m. p. h., 450 lb. carrying capacity. Climbing speed 10,000 ft. in from 8 to 12 min. The spad, Nieuport, Morane, Curtiss-Triplane, S-E-5, Sopwith, Dolphin, and Iserman Albatross single-seaters are examples.

Reconnaissance and photograph machines; slow flying —used for artillery spotting, map making and general reconnoitering. Wing spread from 40 to 60 ft., speed 80 to 100 m. p. h., 800 to 900 lb. carrying capacity. Two or three seaters. Climbing speed 10,000 ft. in 12 to 25 min. Examples are; De Haviland, Bristol, Voisin and Farman.

Battle planes; a two or three passenger machine, driven usually by one large or two fairly good-sized engines. Equipped with a number of machine guns, sometimes a cannon. 70 to 85 m. p. h. The Voisin an example.

Bombers; same general type as reconnaissance machines, but slightly larger. Vary from 45 to 90 ft. in wing spread, carry two to twelve people in addition to war load of bombs and fuel. Speed 75 to 100 m. p. h. Radius of operation 500 to 1000 miles. Climbing speed 7000 ft. in 30 min. Examples: Handley-Page, Caproni, Breguet, the Coudron (twin-engine, French), German Gotha, Friederichshafen, German A E G, and big Curtiss boats.

Naval work; flying boats and hydroaeroplanes of various sizes are used. They compare with reconnaissance machines, 90 to 100 m. p. h. The large 92 ft. wing spread Curtiss flying boats are good examples.

HART NO. 411—The Spad Two-Seater Biplane. Types of Airplanes.

Automotive Industries, The Automobile). See page 902 for name of numbered parts.

Altimeters.

Two types of altimeters in general use, for determining the altitude, are the Mercury Barometer and the Aneroid Barometer.

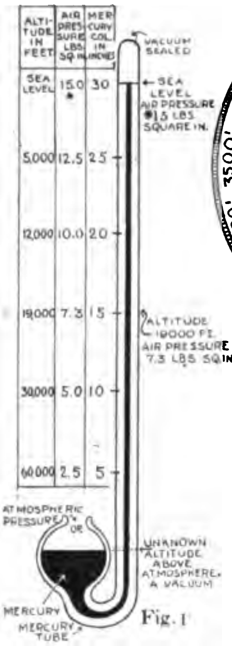


Fig. 1

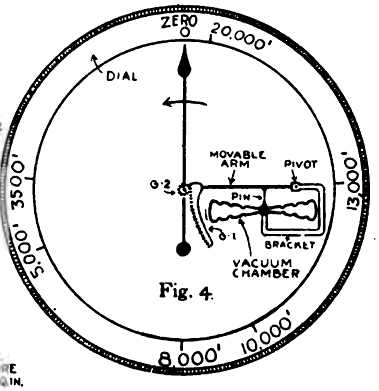


Fig. 4.

Mercury Barometer, fig. 1, indicates altitudes by the rising or falling of the mercury in the glass tube. Note the bulb is filled with mercury and opening (OP) permits the outside atmospheric pressure to act upon the mercury. At sea level the mercury would stand at point indicated at 30 in. high, marked sea level. At an altitude of 19,000 feet the mercury would drop to point indicated, because the atmosphere is less dense or lighter, being only 7.3 lbs. per sq. in. which pressure is not sufficient at (OP) to force the mercury as high as at sea level. Thus the mercury drops, as altitude increases.

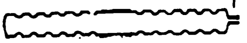
If a height could be reached where there is no air pressure at all, then the mercury would drop the full 30 inches, or to the level of mercury in bulb, indicating no pressure at all at (OP). Note the mercury column does not drop in direct ratio to change of altitude, because higher the altitude, the atmosphere is less dense, and a further distance is required to travel in order to obtain the same variation in pressure. For example, starting from sea level, a movement up and down of 900 feet will cause mercury column to move down and up one inch, whereas, at an altitude of 40,000 feet it would require movement up and down of 4,000 feet to represent 1 inch movement of the mercury column.

The mercury barometer can also be read in inches, for instance, mercury at 25 inches would represent an altitude of 5,000 ft. and air pressure of 12.5 lbs. per sq. inch.

When going below sea level, say down in shafts, the atmosphere increases with the depth, equal to about 1 inch **rise** of the mercury in the barometer for each 900 feet increase in depth—**going above sea level** air becomes lighter and mercury **drops.**

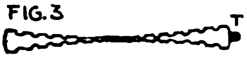
****Aneroid Barometer, fig. 4,** differs in principle. Fig. 2 shows the vacuum chamber before the air is removed. It consists of a metal box of two thin, circular and flexible metallic discs, corrugated on each surface and forming a closed box. If air is pumped out at (T) and sealed, a vacuum is formed inside and the top and bottom would collapse as in fig. 3, because there would be no air pressure inside, yet, on the outside, if at sea level, the air pressure on top and bottom would be *14.7 lbs. per sq. inch, hence reason for its closing together as shown in fig. 3, after all air is withdrawn or a vacuum formed.

FIG. 2



If this vacuum box or chamber fig. 3, is taken to a height where the altitude, say is 19,000 ft. above sea level, the air would be less dense or much lighter, being only 7.3 lbs. to the sq. in. Therefore as the pressure outside of vacuum chamber is not as great, the flexible discs would tend to open out, due to the flexibility of the metal top and bottom of vacuum chamber, trying to assume normal position.

FIG. 3



If an altitude could be reached where there is no air pressure at all, which is an unknown height, the vacuum chamber discs (top and bottom) would open out to their normal position, as outside pressure would be nothing and inside pressure nothing. Therefore the amount of air pressure exerted on the outside of the vacuum chamber causes the top and bottom to move, this movement is taken advantage of mechanically, as shown in fig. 4.

Fig. 4: At sea level the vacuum chamber would be almost collapsed as the *14.7 lbs. pressure outside would force discs together. Therefore a †simplified method is shown, which will indicate the altitude as the air-craft rises. For instance, at an altitude of 19,000 ft. the air pressure outside of the vacuum chamber being 7.3 lbs., the discs of chamber will open out and in so doing, will cause pin to raise pivoted movable arm, causing rack gear (G1) to turn small pinion gear (G2) attached to needle.

The dial is not fixed, but can be turned. It can be set at any altitude or atmospheric pressure. For instance, at various localities the altitude varies, as also does the atmospheric pressure. Therefore the zero (0) point on dial is turned to where needle stands at time of starting the flight and the altitude is determined by the graduations from zero point.

Meaning of Sea Level.

Sea level is a term used to designate a starting point for altitudes. At sea level the atmosphere is more dense and heavier than at greater altitudes. The pressure of the atmosphere at sea level is approximately *14.7 lbs. per sq. inch.

Atmospheric pressure at various altitudes, graduated 5 inches apart, is shown in table, fig. 1. Other distances not marked are: atmospheric pressure at 8,000 feet would be 13.50 lbs. per sq. in.; at 10,000 feet, 10.25 lbs.; at 12,000 feet, 10.00 lbs.; at 19,000 feet, 7.3 lbs.; at 20,000 feet, 6.25 lbs.; at 29,000 feet, 4.85 lbs.; at 37,000 feet, 3.15 lbs.; at 45,000 feet, 2.75 lbs. per sq. inch. For a rough approximate, the pressure decreases ½ pound per square inch for every 1,000 feet of ascent.

Highest Altitude Reached.

On August 12, 1909, Lieutenant Mina of the Italian army, and Mario Piacenzo, in the balloon Albatross, ascended to a height of 11,800 metres (seven miles and 1,754 feet). A spherical bag, with a capacity of 2,000 cubic metres was used. On this occasion, however, the bag was inflated only to the extent of 1,200 cubic metres. The travelers carried with them a large quantity of oxygen to permit breathing in the rarefied atmosphere. At the greatest altitude, they experienced a temperature of 24° below zero, Fahrenheit.

The Albatross appears to have exceeded all previous high records. Eleven thousand and eight hundred metres is equal to 38,714 feet, and the record for height has been 37,000 feet, made in 1862 by two Englishmen, Coxwell and Glaisher. The highest point is Mt. Everest, Northern part of India. 29,002 ft.

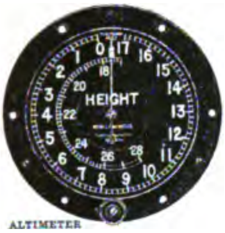
Highest altitude record for airplane, by Capt. Lang, Ipswich, England, Jan. 2, 1919, 30,500 ft.

CHART NO. 412—Method for Determining Altitudes.

---

*The figures in table, fig. 1 are based on an air pressure at sea level of 15 lbs. per square inch. The correct pressure is approximately 14.7 lbs. per sq. inch. **Aneroid is a Greek compound, expressing, "without fluid."

†Fig. 4 is not exact construction, but explains the principle. See page 921 for exact likeness of an Altimeter dial.



Dial of the Short & Mason Altimeter. Needle turns to left. Reading in thousands of feet, as 1, means 1,000 and so on around to 17, which is 17,000 feet. Lower reading is merely a continuation after 17.

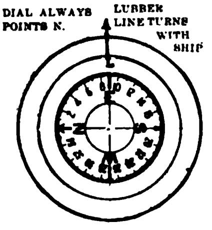


FIG. 26 AIR COMPASS

Air Compass: Dial is supported on a pivot and always points N. Numerals are every 20 degrees. The last cipher is omitted to save space, as 2 means 20, 30 means 300 degrees. etc. From N to N is 360°. The bowl turns with ship and lubber line (L) being on bowl turns with it. Lubber line is now opposite E or 90° from N, therefore ship is traveling due East.

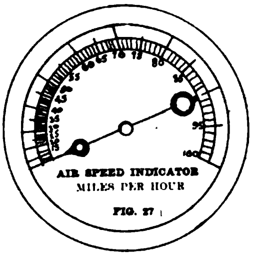


FIG. 27

Air Speed Indicator indicates relative wind pressure. Instrument on dash is connected by copper tube to nozzle fig. 30) located forward with nozzle (c) pointing to direction of motion. The pressure of wind or air velocity, in miles per hour is thus indicated.

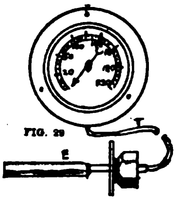


FIG. 29

Extension Thermometer: Indicates temperature of water or oil circulating through engine in degrees Fahrenheit. A similar device to fig. 9. page 188, but this instrument is placed on dash. Tube (E) contains ether, which is connected to circulating system of engine. Expansion of the ether causes needle to indicate temperature. See fig. 22, page 917.

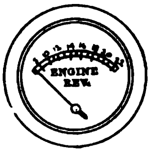
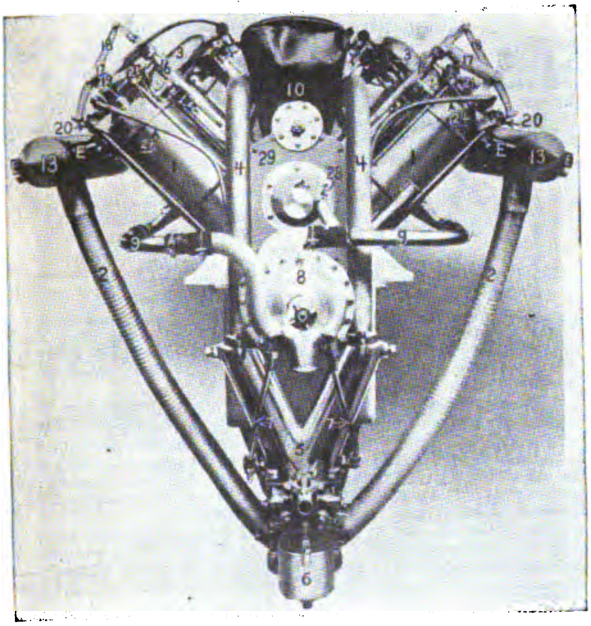


FIG. 28

Tachometer is an instrument showing revolutions of engine crank and is connected with Curtiss engine at 28. 2 means 20, 10 means 1,000, 22 means 2,200 r. p. m., etc.

FIG. 30



Rear view of Curtiss 8 cyl. V-type engine.

Curtiss Airplane Engines.

Model OX: Bore 4 in., stroke 5 in. 1400 r. p. m. developing 90 h. p. **Cylinders,** 8 V-type with cylinders 90° apart. **Valves** overhead, one intake, one exhaust operated by push rods and overhead rocker arms; **weight** with propeller hub, without oil or water, 390 lbs.; **carburetion,** Zenith, see page 182; **oiling,** force feed to all bearings; **cooling,** water, centrifugal pump; **ignition,** Berling high tension, 8 cylinder magneto, with two spark plugs per cylinder. **Valves** seat is machined direct in cylinder head in a similar manner as that shown in the Hall-Scott, page 912. In the Curtiss OX2 and Hall-Scott it is necessary to remove cylinder to remove valves. **Pistons,** aluminum alloy. **Inlet valves** are nickel steel and **exhaust,** tungsten steel. **Steel water jackets** brazed to cylinders. **Cylinders** are staggered and **connecting rods** are placed side by side.

Model OXX is the same, except ¼ inch larger bore than "OX" and is rated at 100 h. p. at 1400 r. p. m. Illustration shows the rear view of the OX and OXX engine.

Model V2: Bore 5 in., stroke 7 in.; 1400 r. p. m. developing 200 h. p. **Cylinders,** 8 V-type. Similar to OX except two high tension magnetos are used and two Zenith carburetors placed on the side. Weight is 690 lbs.

Twelve Cylinder: Bore 5 inch, stroke 7 in., h. p. 250 at 1,400 r.p.m. On some of the Curtiss engines, a thin aluminum liner is placed between crank case and cylinders for flying at altitudes below 6,000 feet, in order to give a lower compression which does not result in pre-ignition at low altitude. For high altitude work these liners are removed.

Name of Curtiss Parts.

1, cylinders; 2, hot air pipes to carburetor air intake; 3, inlet manifold; 4, inlet pipes; 5, water jacketed inlet; 6, Zenith Duplex carburetor; 7, hot water pipes to inlet; 8, water pump; 9, water pipes; 10, *magneto; 13, hot air jacket surrounding exhaust manifold; 16, push rod; 17, inlet rocker arm; 18, exhaust rocker arm; 19, spark plug; 20, exhaust valve; 21, inlet valve; 28, tachometer connection; E, exhaust.

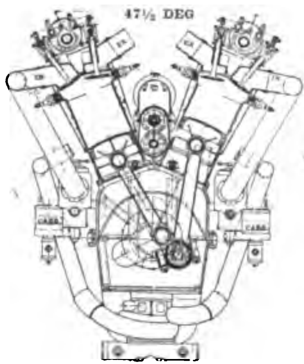
Under 1, on cylinder on right, is breather pipe. Oil pump is located below and in rear of water pump.

See page 918 for firing order of Curtiss engine.

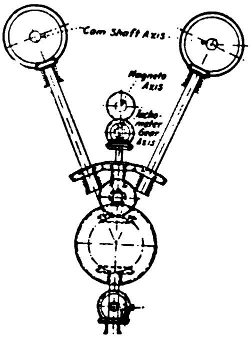
CHART NO. 413—Airplane Instruments. Curtiss Airplane Engines.

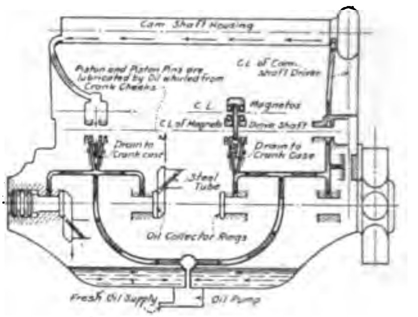
---

*The Berling D-81-X2, 8 cyl. high tension, single spark magneto was used on the Curtiss engine on the JN4 training plane. Magneto armature revolves twice crankshaft speed. It is of the usual high tension magneto principle with distributor designed for 8 cylinders. See page 927.



CROSS-SECTION RENAULT TWELVE-CYLINDER ENGINE





RENAULT ENGINE OILING DIAGRAM

Renault Airplane Engine.

Is a 12 cylinder V-type with cylinders placed at angle of 47½°. Bore 125 mm., stroke 160 mm. Cylinders are steel and are almost a duplicate of the Mercedes, page 916.

Valves overhead **type, operated by** overhead camshaft. Two valves **2⅝ in.** di. per cylinder. Valve port is 2 13/32 in., valve stems 7/16 in. di., valve seat is set at 45° and ½ in. thick. They open 15/32 in. **Pistons cast iron, 3¾ in.** in length. There are eighteen **11/32 in.** holes drilled in skirt. **Connecting rods** articulated type of I-beam section in which the shorter rod is attached to a boss on the master rod by a pin to form a hinge. **Crankshaft** carried in four babbitt lined bronze shells secured to ribbed--steel bearing caps. **Gearing system** is shown in center illustration. The inclined shafts operating at three times camshaft speed, driving camshafts through straight bevel gears. **Oiling system** is shown. Oil is carried through ducts through copper tubes up to and through overhead camshaft case and returns down through the distributing gearing case to oil sump. **Ignition** consists of 4 magnetos mounted on the same axis driven through spur gears.

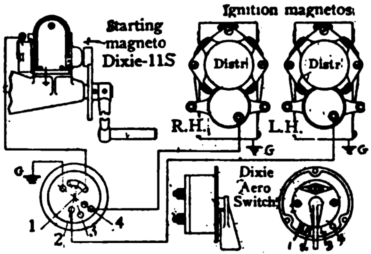


Fig. 23—Wiring diagram of Dixie 11-S starting magneto, with control switch and two service magnetos.

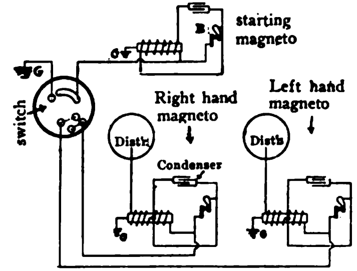


Fig. 24—Internal wiring diagram of Dixie 11-S starting magneto, control switch and two service magnetos

Magnetos for Airplane Engines.

In the 8 and 12 cylinder magnetos a field structure, rotor and cam are sometimes employed which produce four sparks per revolution of the magneto shaft, two of the sparks being of one polarity and two of opposite polarity.*

The speed at which magneto should be driven is as follows: Dixie magnetos will deliver one, two or four sparks per revolution of the drive shaft and when installed on four cycle engines, run as follows:

1 Cyl.	½	engine speed,	with 1 lobe cam.
2 Cyl.		engine speed,	with 1 lobe cam.
3 Cyl.	1½	engine speed,	with 1 lobe cam.
4 Cyl.		engine speed,	with 2 lobe cam.
6 Cyl.	1½	engine speed,	with 2 lobe cam.
8 Cyl.		engine speed,	with 4 lobe cam.
12 Cyl.	1½	engine speed,	with 4 lobe cam.

Therefore during two revolutions of crank shaft on an 8 cylinder engine 8 sparks would be produced, or 4 per rev. On a 12 cylinder engine, 12 sparks would be produced during 2 rev. of crank, as armature makes 3 rev. to 2 of crank and 4 sparks per rev. or 12 sparks per 3 rev.

****Where magnetos have separately driven distributors,** as per page 918, then a single contact (C) is on distributor of magneto (per fig. 14), which connects with separate distributor.

Double ignition or connection for two synchronized magnetos, is shown in figs. 23 and 24. Note switch position below (assuming that upper part of switch lever is connected with ground (G) instead of starting magneto):

Switch position 1, both magnetos generating; switch position 2, L. H. magneto short-circuited or off, R. H. generating; switch position 3, R. H. magneto short-circuited or off and L. H. generating; switch position 4, both magnetos off or short circuited.

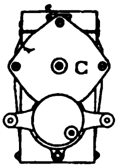


Fig. 14—Magneto

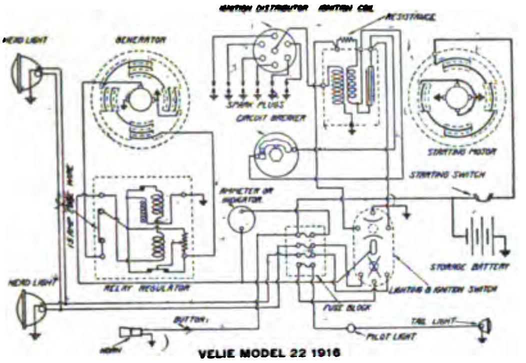
Dixie 11S starting magneto is an auxiliary source of current with which to operate the ignition on airplane engines, whereby a shower of sparks can be produced at slow cranking speeds. It carries a breaker (B) for interrupting the current which it supplies to one of the magnetos when starting. The starting magneto is operated by hand which drives it 4 times as fast as the regular running magnetos. As long as the platinum points of the ignition magnetos are closed, any connection with the starting magneto is ineffective, but as soon as the platinum points separate, the primary of the ignition magneto, which is connected to the starting magneto is then in series with the starting magneto, and a shower of sparks for ignition is produced, while the points remain separated.

The starting magneto is connected to the regular ignition magnetos as shown in figs. 23 and 24. There are four switch positions as follows: Switch position 2, left hand magneto is connected to starting magneto; switch position 3, right hand magneto is connected to starting magneto; switch position 1, both magnetos running, starting magneto disconnected; switch position 4, both magetos off or short circuited. The spark is produced from the ignition magnetos during the time the contact points are open, which is for a duration of about 27 degrees.

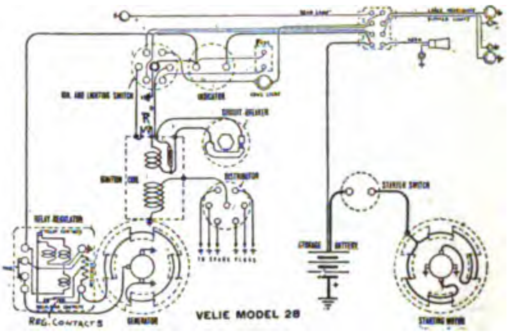
IART NO. 414—Renault Airplane Engine. Splitdorf-Dixie Airplane Magnetos.

The magnetos can also be of the unidirectional type, meaning that the spark is of one polarity only. There are four magnetic breaks within the magneto, but owing to the use of a cam of slightly different construction. only two sparks, both of the same polarity can be produced.

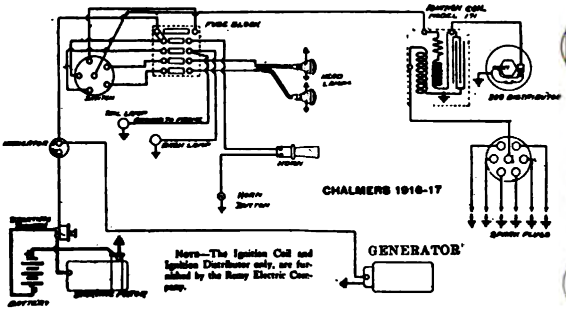
See figs. 19 to 26, page 293, for distributors where a single magneto has 8 or 12 segments.



VELIE MODEL 22 1916

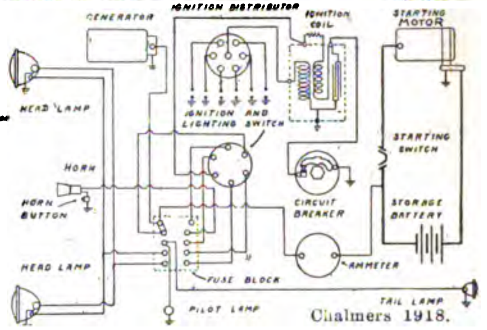


VELIE MODEL 28

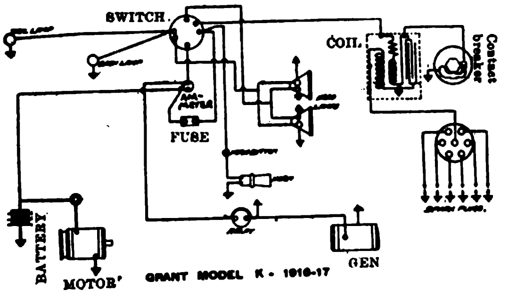


CHALMERS 1916-17

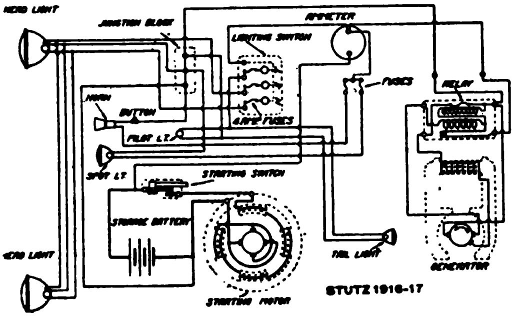
Note—The Ignition Coil and Ignition Distributor only, are furnished by the Remy Electric Company.



Chalmers 1918.



GRANT MODEL K - 1916-17



STUTZ 1916-17

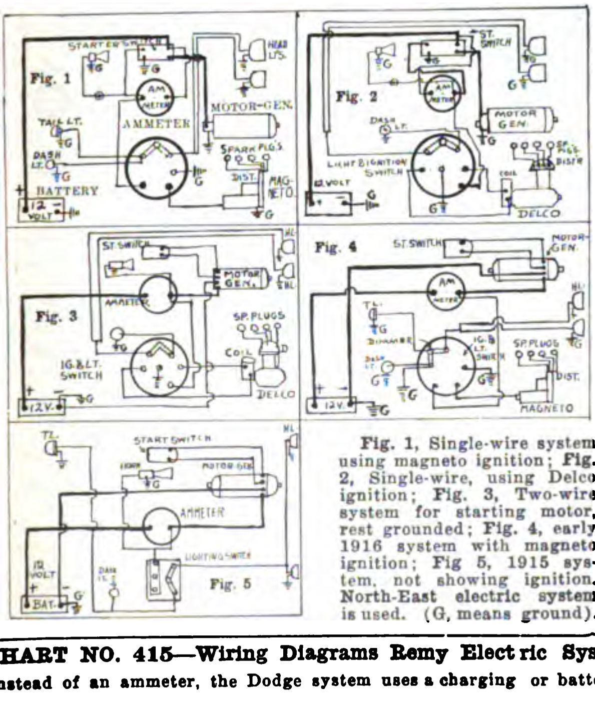


Fig. 1, Single-wire system using magneto ignition; Fig. 2, Single-wire, using Delco ignition; Fig. 3, Two-wire system for starting motor, rest grounded; Fig. 4, early 1916 system with magneto ignition; Fig 5, 1915 system, not showing ignition. North-East electric system is used. (G, means ground).

Dodge Electric Systems.

The North-East system on page 369 and 370 is the standard model "G" used on the Dodge since fall of 1916, with slight internal modifications. For ignition, the Dodge has used the high tension magneto, Delco system and since March, 1918, the N. E. model "O" system (fig. 7) has been used.

On the 1915 and early 1916 cars, the model D electric system (fig. 5) was used. With this system a cut-out and relay type of regulator were contained in the starter-generator unit (this can be determined when there are 4 terminals on starter-genrator, see fig. 6).

The model "G" system differs from all previous models in that it has a third-brush regulation instead of a current relay type regulator, which formed a part of all preceding N. E. models. The cut-out however is retained, but it is now enclosed in the housing with starting switch (pages 369 and 370), instead of in generator itself, therefore only one connection to starter generator and one grounded terminal.

Charging rate is 6 to 7 amperes at 16 m. p. h. up to 21. Over 21 the rate decreases as low as 3 amperes. Generator

—continued on page 924.

CHART NO. 415—Wiring Diagrams Remy Electric Systems. Dodge Electric Systems.

Instead of an ammeter, the Dodge system uses a charging or battery indicator, see page 370 and 410 for principle.

—continued from page 923.

output can be adjusted as low as 4 amperes at 1800 r. p. m. at 15 volts, or as high as 10 amperes at same voltage, by moving third-brush stud in rear of generator, per instructions on pages 733 and 369, 370.

Charging rate can be tested by inserting an ammeter between positive terminal of battery and cable attached thereto. Measured this way, it will be found to be from 1 to 2 amperes less than total generator output, even with lamps off, due to ignition consumption.

Actual output of generator can be measured with a 15 ampere ammeter inserted between No. 8 binding post (on illustration, page 370), and positive terminal of charging indicator.

Fuse is located on commutator end of starter-generator. It is the first place to look in case of failure of current supply—see page 733 and 370.

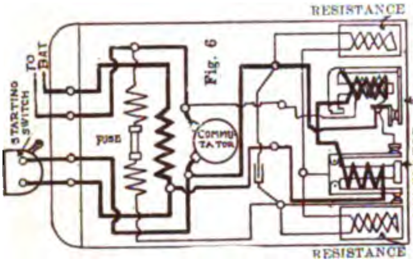
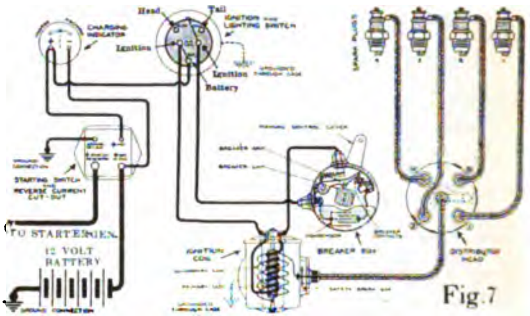
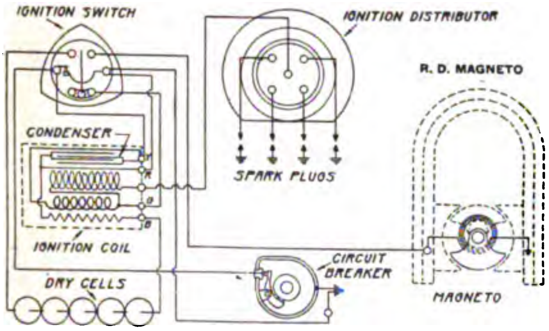
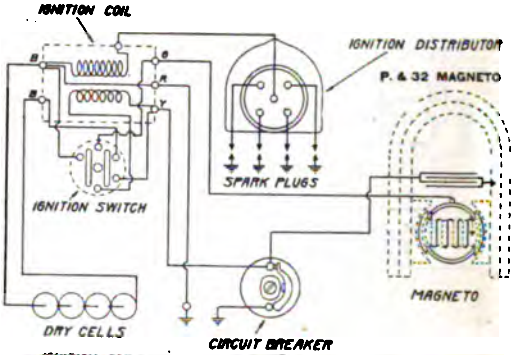


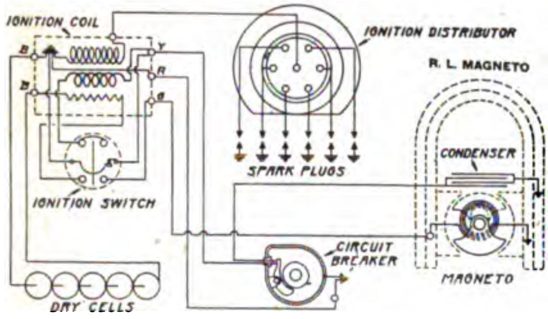
Fig. 6—Internal circuit of North-East Electric System on 1915 and early 1916 Dodge. Ignition and light circuits not shown.

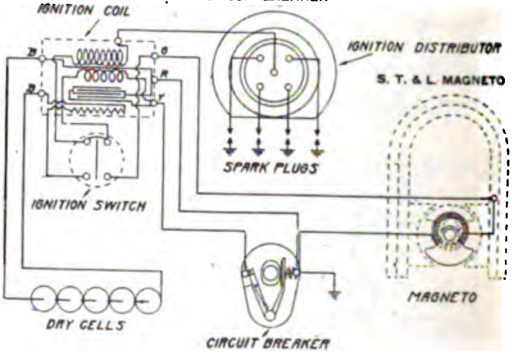


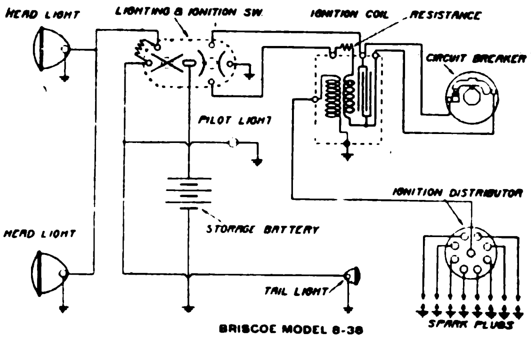
Circuit Diagram of the Model O Ignition System on the Dodge Brothers Motor Car











BRISCOE MODEL 8-38

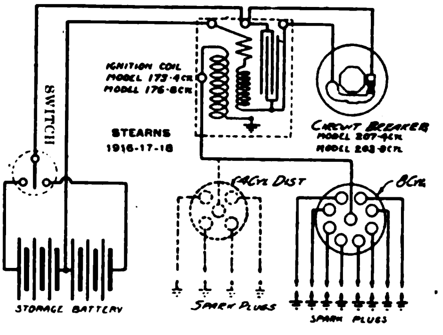


CHART NO. 416—Dodge Electric Systems—continued. **Remy Magneto and Wiring Diagrams.**

A Wiring Diagram Book—Those desiring a book dealing exclusively with wiring diagrams write A. L. Dyke, Pub., St. Louis, Mo. Another book dealing exclusively with storage batteries is also for sale. Send for circulars.

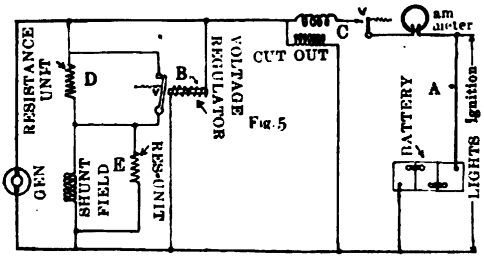


Fig. 5

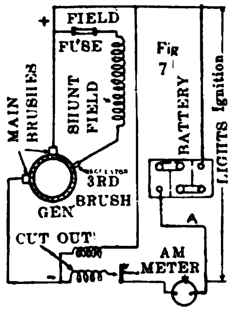


Fig 7

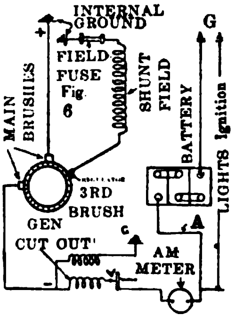


Fig. 6

Bijur Constant Voltage Regulation Generator.

The voltage regulation system is shown in fig. 5. With this system the amount of current generated depends upon the state of charge of battery and the amount of lamp load in use. With a discharged battery the voltage is a minimum, but as the charge of battery proceeds the voltage of battery will increase, so that the difference in pressure between generator and battery is continually diminishing. If battery is fully charged, then generator charging current will be small. Therefore the charging current is variable and is independent of the speed, and tapers from maximum with a discharged battery to minimum with a fully charged battery.

After generator reaches a speed at which it develops its normal voltage, the voltage does not increase with speed, but remains constant.

Voltage regulation permits of a battery being charged at a high current rate when battery voltage is low and a much lower rate when battery voltage is high.

Operation of cut-out. (C, fig. 5): Its purpose is to connect and disconnect the generator to battery when generator is at rest or at very low speeds. It has a shunt and series winding. The shunt is connected across the generator so as to receive the full voltage of generator and when machine attains speed at which it develops 6.5 volts, the shunt winding is sufficiently energized to close the cut-out armature (V). The series winding is connected in the main circuit and current flows through it and its pull reinforces the pull due to the shunt winding and firmly holds the cut-out armature (V) closed. When the speed of generator is decreased to a speed where it generates voltage lower than battery, then a momentary discharge from battery through the series winding demagnetizes the coil (C) and cut-out is opened.

The voltage regulating unit (B) fig. 5, has a single winding connected across the generator. It is opened and closed owing to amount of pressure developed by generator. Below 7.75 volts the resistance (D) is cut out of field circuit, path being around it through V, giving generator chance to build up. Above 7.75 volts, coil (B) pulls V to it, which throws resistance (D) into field circuit which automatically reduces the generation. While running, this regulator armature vibrates rapidly cutting the resistance into and out of field circuit by means of vibrator V. Thus the pressure never goes above 7.75 or lamps would burn out.

The other resistance unit (E) which is connected in parallel with field winding is to absorb the field energy when the regulator contacts are open and reduce sparking at contacts.

Ammeter: In this particular system the meter is connected between generator and battery which indicates generator output only and does not show a discharge when generator is at rest. On some cars the meter is connected at branch (A) and with generator in operation, meter will indicate output less the current consumed by lights and other devices.

Adjustments. A hole is provided on regulator box for adjusting voltage regulator and another for cut-out. Turning adjusting nut to right on cut-out raises the cut-in voltage. Turning adjusting nut on voltage regulator to right raises generator voltage.

Before adjusting cut-out disconnect one of battery terminals and place head light switch on. Voltmeter leads should be clipped to generator brushes, engine run slow, gradually increasing speed. Adjustment should then be made so cut-out will close at 6.5 volts, the voltage will then immediately drop on closing, which indicates it has closed.

In setting voltage regulator, connect generator to battery having specific gravity of 1,250 and light switch off. Voltage should be measured across brushes as above. Run engine at speed so generator will turn 1000 to 1400 r. p. m. and tension of spring regulated until 7.75 to 7.8 volts is generated. Always set adjusting nut tight after adjusting.

Generator can be used without battery, if lights are on, otherwise resistance unit is liable to burn out.

Wiring: A single or double wire system can be used wih this generator.

Care: (1) Every two weeks 2 or 3 drops of thin mineral oil should be put in oilers; (2) Every two weeks **reverse regulator disconnect plug** by pushing it in to unlock, then turn and reverse its connections; (3) Inspect brushes every 1000 miles, to see that they make good contact and move freely up and down. See pages 408, 409, 404, 406.

The Bijur Constant Current Regulation Generator.

The single wire system is shown in fig. 6 and the two wire system in fig. 7, either can be used.

With the constant current *third-brush regulation the generated current is independent of the voltage of the battery or the amount of lamp load connected, but depends upon the speed at which machine is driven and position of the regulating third-brush with respect to the two main brushes. The cut-out (V) closes when generator reaches 6.5 volts, or generator speed of 500 or 600 r. p. m. With increasing speed the current increases to maximum value, at speeds about 1000 to 1600 r. p. m.; at higher speeds current gradually decreases.

Adjustment: Moving the brush (by loosening nuts) in direction of rotation of armature increases generator output, in opposite direction, decreases. At 1400 to 1600 r. p. m. of generator (20 to 25 miles, car speed) the amperage should be not less than 12 or more than 15. Approximately a shift of third-brush 1/16" will change output 2 to 3 amperes. If adjusted on car, remove generator cables and tape ends, then place back after adjusting and run generator and test. Two or three trials may be necessary. Best results are obtained after running car when generator is hot and connected to battery with 1250 specific gravity (s. g.)

Fuse: A 6 to 12 ampere fuse is placed in field to protect coils burning out.

It is not feasible to supply current for lights from a constant current generator without a battery being connected in circuit, for instance, if lamps require 7 amperes and generator at speed, delivers 15 amperes, the generator voltage would rise until the additional 8 amperes not required by the lamps will be forced through the lamp circuit and burn them out.

Care of generator and starting motor—see pages 407 to 421.

CHART NO. 417—Difference Between a Generator using Constant Voltage Regulation and o using Constant Current Regulation—Bijur as examples.

*See also page 389, explanation of third-brush principle. See pages 543, 546; electric systems 1918 cars.

FOR MODELS, A, B, D, F, O and T MAGNETOS

Fig. 1

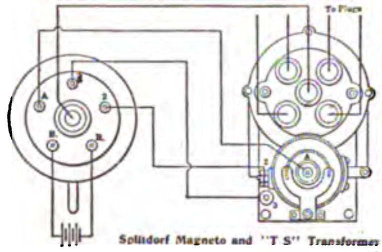
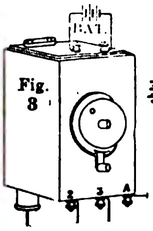


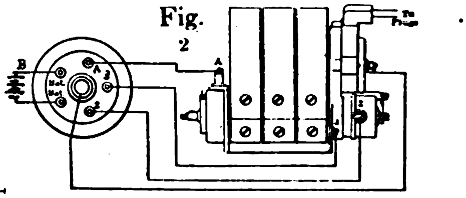
Fig. 3



Splitdorf Magneto and "T S" Transformer

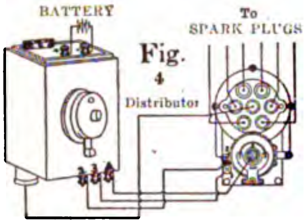
FOR MODELS W, X, Y AND Z MAGNETOS

Fig. 2



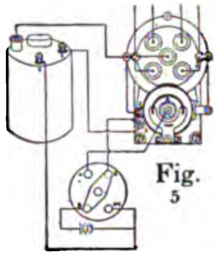
Splitdorf Magneto and "T S" Transformer

Fig. 4



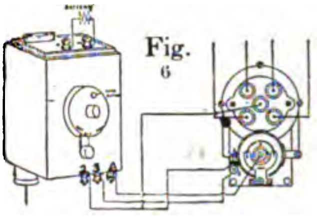
Splitdorf Magneto and Dash Transformer

Fig. 5



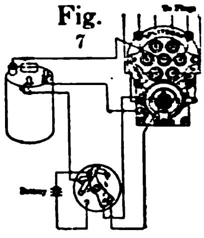
Splitdorf Magneto and Tube Transformer

Fig. 6



Splitdorf Magneto and Dash Transformer

Fig. 7

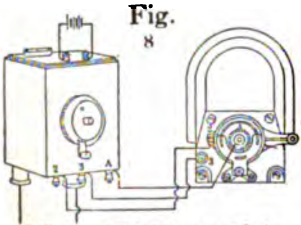


Splitdorf Magneto and Tube Transformer

FOR MODELS S AND SS MAGNETOS

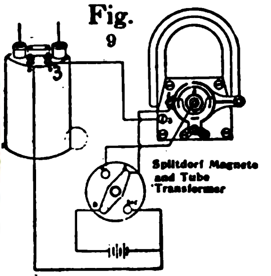
FOR MODEL G and H MAGNETOS

Fig. 8



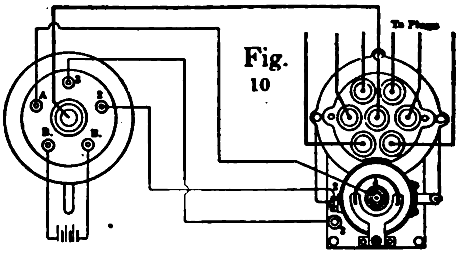
Splitdorf Magneto and Dash, Transformer

Fig. 9



Splitdorf Magneto and Tube Transformer

Fig. 10



Splitdorf Magneto and "T S" Transformer

Fig. 14

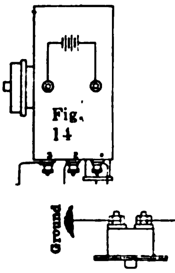
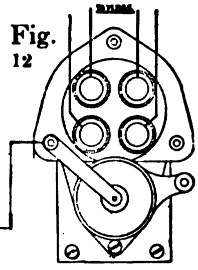


Fig. 12



MODEL TT MAGNETO

Fig. 11

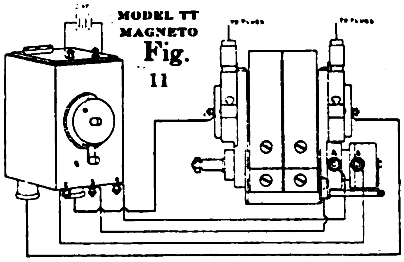
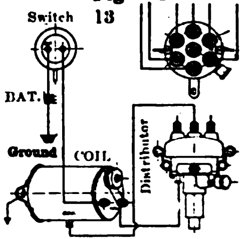


Fig. 13



Wiring Plan of Splitdorf Timer-Distributor

Splitdorf Magneto Wiring Diagrams.

Many of the systems are similar. Note diagrams show both the dash type and tube type coils. For instance, fig. 3 is dash coil for models A, B, D, F, T, W, X, Y, Z magnetos, whereas figs. 1 and 2 show connections to the tube type coil. Many of the above ignition systems were used several years ago, but are shown as a reference for older model cars.

Magneto in fig. 1 and coil in fig. 14 would constitute the model O system. Magneto in fig. 2 and coil in fig. 3 would represent the model X system formerly used in the Maxwell "40." Fig. 12 is the EU4 magneto. See pages 290 to 293 for Splitdorf Dixie magneto and pages 228 for Splitdorf coil connections.

Berling Magneto.

Figs. 9 and 10 show the two-spark system. When switch is in position (1), primary winding is short circuited and magneto is "off." When on (2), magneto operates as a single spark magneto. When in this position (2), end of secondary is grounded and is position for starting, because at slow speeds all of intensity of magneto is concentrated to one spark plug instead of being divided. When on (3), which is running position at full speed, magneto supplies current for the two spark plugs in each cylinder and current is divided between the two. Breaker points are set .016 to .020 in.

BERLING TWO-POINT HIGH TENSION MAGNETO

Fig. 9

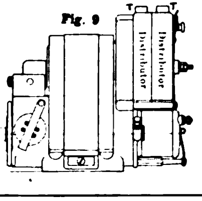
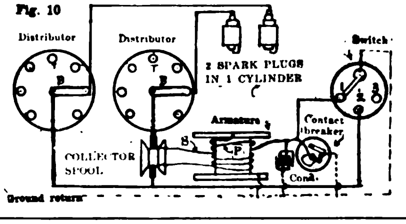


Fig. 10



Another two-spark system is shown on page 283.

CHART NO. 418—Wiring Diagrams Splitdorf Magneto Systems. Berling Two-Spark Magneto.

See page 864F for advertisement of a large Book of Wiring Diagrams in blue print form. This book also deals with Storage Batteries and Electric Systems—send for circulars.

Stromberg Model "L" Carburetor. Berling Magneto.

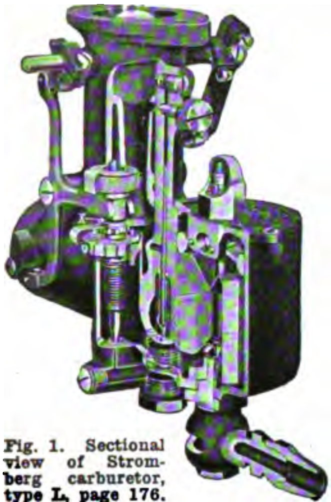
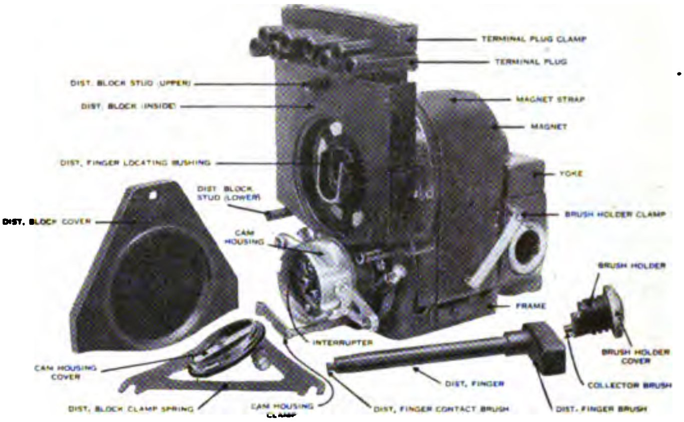
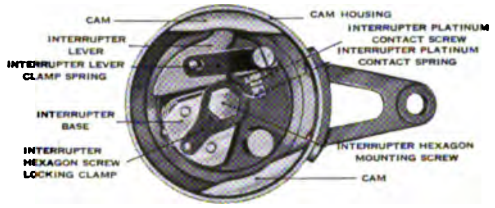


Fig. 1. Sectional view of Stromberg carburetor, type L, page 176. The only difference between the type L and M, page 176 is in the "economizer" action, or the lifting of the high speed needle valve (A) automatically. This needle valve (A) on type (M) is hand regulated.




CAM
INTERRUPTER LEVER
INTERRUPTER LEVER CLAMP SPRING
INTERRUPTER BASE
INTERRUPTER HEXAGON SCREW LOCKING CLAMP
CAM HOUSING
INTERRUPTER PLATINUM CONTACT SCREW
INTERRUPTER PLATINUM CONTACT SPRING
INTERRUPTER HEXAGON MOUNTING SCREW
CAM

Berling type D-81x-2, high tension 8 cyl., single spark magneto as used on the Curtiss training planes.

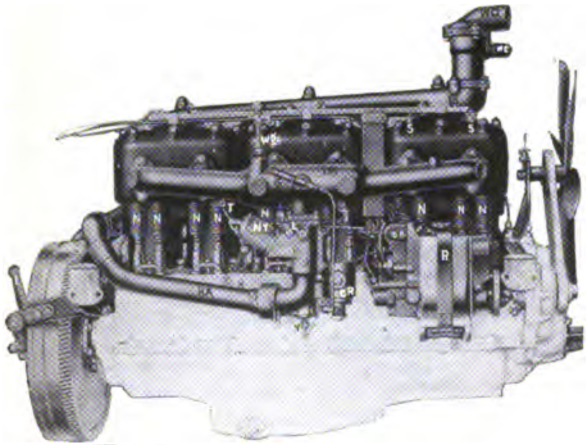
The interrupter is shown to the left.

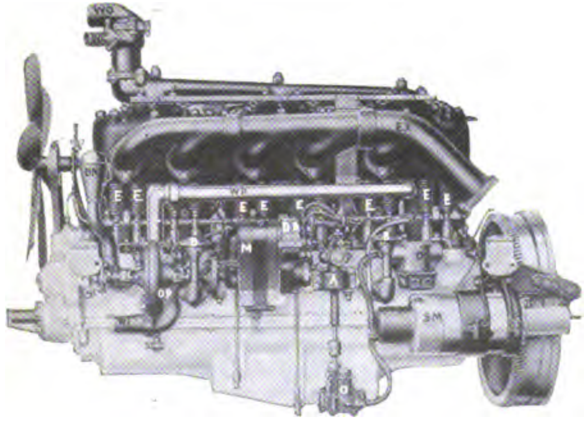
Pierce-Arrow "Dual" Valve Engine.

Dual valves, mean two inlet and two exhaust valves to each cylinder. The Stutz engine, page 109, uses dual valves but they are placed overhead instead of to the side as below. The White also uses a "T" head cylinder with two inlet and two exhaust valves per cylinder.

Advantages of dual valves is this: It is well known that greater power, especially at higher speeds is obtained by using large valves. For instance, in standard practice the rule is to have the valve diameter one-half that of the bore of cylinder. For a 4½ inch bore, a 2¼ inch valve is used. In order, however, to get the maximum possible power, a 3 in. valve with a ⅝ in. lift would give greater power, but to do this would result in noisy valves, due to the heavy valve spring required to close them promptly, and also on account of the tendency of the valve head to warp out of shape.

Therefore by using two smaller valves of 1½ in di., with a ⅜ in. lift, the same opening area as the single 3 inch valve is obtained. This gives the maximum power and a very quiet valve action, due to the use of light valve springs.





Name of Parts.

Pierce-Arrow: cylinders of 3 blocks, "T-head;" **valves** on side; **fuel** fed to carburetor by pressure; **ignition,** Bosch high tension magneto with a Westinghouse generator system as a reserve. The two systems are independent and connect with two sets of spark plugs. **WO,** water pipe from engine to radiator; **WC,** water bypass from thermostat; **WI,** water pump connection to radiator; **OP,** water pump; **WP,** water pipe; **S,** spark plugs; **N,** inlet valves; **HA,** hot air intake to carburetor; **CR,** carb. float chamber; **IM,** intake manifold (hot water jacketed); **R,** generator; **DR,** generator distributor; **G,** gasoline primer; **Y,** carburetor adjusting needle valve (controlled from seat); **E,** exhaust valves; **M,** magneto; **EX,** exhaust manifold; **BR,** oil filler; **O,** oil pump; **A,** oil pump drive gear case; **D,** electro magnetic starting switch for starting motor; **SM,** starting motor with automatic gear shift.

CHART NO. 419—Stromberg Carburetor. Berling Magneto. Pierce-Arrow Dual Valve Engine.

*K-W Magnetos.

The K-W magneto differs from other magnetos in many ways, and possibly the clearest information that can be given, is by careful study of the diagrams and accompanying explanation.

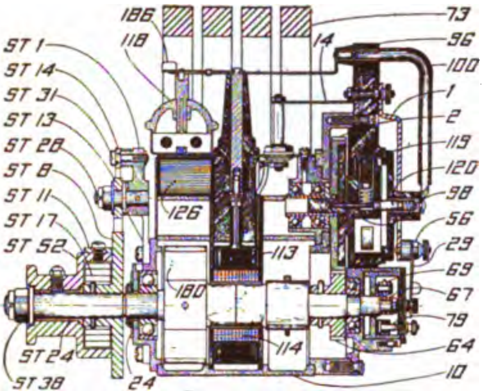


Diagram "A."

Diagram "A" shows a longitudinal sectional elevation of the model HK magneto. By referring to the numbers in the following description, a clear idea may be obtained of the function of the various parts.

1	Bridge or spider.	98	Distributor brush holder.
2	Distributor gear.	100	High tension lead.
10	Base.	113	Secondary winding.
14	Low tension bus bar.	114	Primary winding.
24	Dust cap or cover.	118	Safety spark gap.
56	Switch binding post.	119	Secondary distributor brush.
64	Driving pinion.	120	Secondary contact plunger.
67	Cam.	126	Condenser.
69	Rocker arm roller shaft.	180	Rotor.
73	Magnets.	186	High tension bus bar.
79	Plunger for primary circuit.	29	Retainer spring.
96	Distributor block.		

Illustration "B" shows the rotor (which is the only revolving part in the K-W magneto) and the complete assembled winding. The rotor is made up of soft Norway sheet iron stampings, which are riveted together and very accurately machined, as these rotor blocks, which run on high grade annular ball bearings, have only .003" space between their face and the face of the pole pieces. The rotor blocks are made in two halves and are held on the shaft by a taper pin and are mounted at right angles to each other.

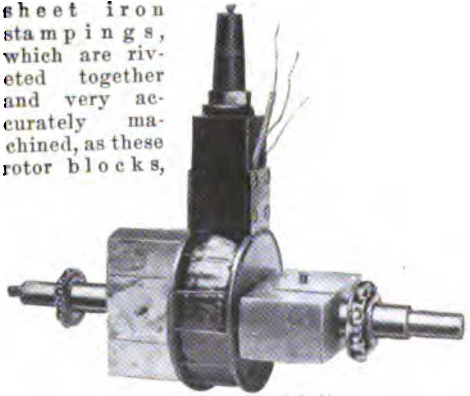


Illustration "B."

In mounting the winding between these rotor blocks, the pin is taken out of one half, and the rotor block is withdrawn from the shaft to allow the winding to be placed in the center.

The winding: Complete assembled winding (illustration C) consists of a primary winding of heavy copper wire and a secondary winding (see also diagram A), which is made up of a great number of turns of very fine wire, these coils being wound circular in shape, assuring the largest number of turns with the least length of wire, which makes the most efficient type of coil.

Illustration "C."

These windings are given an impregnation of high grade insulating compound by the vacuum process and the secondary winding is given 27 separate coats of varnish, each one baked twenty-four hours, which thoroughly insulates it from the primary winding and also assures it being as near water and oil proof as it is possible to make any high tension coil. These windings are assembled with the secondary outside of the primary and then enclosed in a brass housing with a hard rubber plug, through which the high voltage secondary is carried to the distributor brush of the magneto.

The condenser: No. 126, in diagram "A," is made up of a number of alternating sheets of tin foil and mica, every other sheet of tin foil being connected together, which makes two series of tin foil layers separated from each other by sheet mica. Each sheet of mica is tested separately before being used with 5000 volts for break down and after it is assembled it is given a test of five to six times the normal working voltage to which it is subjected, assuring reliability under adverse conditions.

The safety gap, No. 118, diagram "A," is a necessary part of any high tension magneto, its object being to form a path for the high tension current to jump across in case a secondary cable that leads to the spark plugs, should be off when the engine is running. This safety gap, as its name implies, prevents the winding from burning out, for as long as their is a path for the high tension current to pass through, it will never puncture the insulation of the secondary winding.

The magnetic field of the magneto is composed of four horse shoe magnets No. 73, in diagram "A," which are mounted on two cast iron pole-pieces, spaced 90 degrees apart. The rotor, No. 180, revolves within this magnetic field, and as the rotor blocks are spaced 90 degrees apart, there is a current wave four times to the revolution of the magneto.

---

*See also, pages 256, 296, 288 and 832 for additional information on K-W magnetos.

When the rotor is revolved within this magnetic field, the magnetic lines of force are cut or distorted and an electrical current is set up in the primary winding, which is carried up through part No. 14 to bridge No. 1, then through spring No. 69 to the circuit breaker cap and through the contact points in the circuit breaker back to the other side of the winding, completing the circuit.

When the current has reached its highest point, the circuit breaker-points are open and the change of the magnetic flux causes a high voltage to be set up in the fine wire secondary winding. This induction is assisted by the condenser, which is connected across the circuit breaker points, absorbing the spark which would occur if the condenser were not in circuit and also assisting by the discharge which takes place immediately after it is loaded.

The high tension current is carried up through the hard rubber plug to the bus bar No. 186, then through lead No. 100 to the distributing brush, which distributes it to the different segments on the distributor block, these segments being connected by high tension cables to the different spark plugs on the engine.

The distributor block is made of hard rubber into which is molded brass segments, one for each cylinder. The distributor brush which turns with the gear of the magneto is also molded of hard rubber and carries a carbon brush, which bears lightly on these segments as it passes, and the magneto is timed so that the circuit breaker points open and the high tension current is generated just at the instant this brush goes to the segment.

The K-W Circuit Breaker.

The entire circuit breaker is removable. Release spring No. 29 by pushing it aside. Pull out complete breaker box and remove cover nut No. 79. This allows removal of circuit breaker cap and gives access to breaker parts. The same type of circuit breaker is used on all K-W high tension magnetos, and is shown by diagram "D." It is arranged to have 30 degrees of advance or retard for regular work.

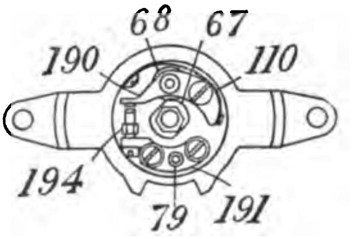


Diagram "D."

When the points fail to separate or when the distance is too far apart, adjust part 194 with small screw driver inserted through hole for that purpose in housing. The proper distance apart is $\frac{1}{64}$". A gauge is sent with every magneto.

The firing point of the magneto is just when the points are beginning to open or break circuit, **not** when they touch.

To Open Distributor.

Remove the high tension lead No. 100, by turning it to right, which releases it at bottom. Unscrew nut at top of spider, and remove the bridge or spider No. 1, thus releasing cap on distributor block and giving view of distributor and brush No. 119.

*Impulse Starter.

Illustration "F" shows the impulse starter as applied to the model HK magneto and diagram "E" shows a sectional view of the impulse starter only.

Illustration "F."

The impulse starter consists of two separate members, one of which is called the ratchet and one the starter case. The ratchet is fastened directly to the rotor shaft of the magneto and the case connects to the coupling, which is fastened to the shaft that drives the magneto. Interposed between these two members is a clock spring which performs the function of driving the rotor when the starting mechanism is used.

When the engine is to be started, the trigger, ST-14 is pressed, which allows the hook dog ST-13 to drop into the notch on ratchet ST-6, so when the starter case ST-2 is turned by the drive shaft, the ratchet remains stationary, and the clock spring inside the case is wound up while the case is moving 80 degrees, which brings starter dog ST-11 around to the position where it moves the roller on ST-13, which in turn moves this hook ST-13 out of the notch on the ratchet.

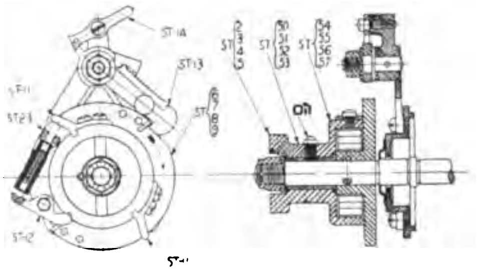


Diagram "E."

When this hook dog releases the ratchet, it is given an impulse forward by the clock spring, and is thrown back to its original position, as shown in the diagram. While this rotor is being moved rapidly by this spring, the circuit breaker points are open, causing the function of producing the spark.

---

*See also, page 832. Manufacturers of K-W Magnetos; K-W Ignition Co., Cleveland, Ohio.

The starter continues to operate until a predetermined speed has been reached, when the hook dog is thrown up and latched and the magneto is driven direct. The speed at which the starter throws out of engagement, is determined by the tension of the cushion spring on the hook dog.

To Time Magneto To The Engine.

First: Turn over crank shaft of engine, placing engine from 3° to 5° past top dead center on firing stroke.

Second: Mount and connect magneto so that the tripping mechanism will trip the impulse starting device.

Illustration "G."

Illustration "G" shows K-W high tension magneto, known as model TK, while diagram "J" shows a cross sectional view of this magneto. It will be noted that the principle of the model HK and TK magneto is exactly the same, the only difference being in the size of the magnetos and their appearance. The same principles of design and construction, are employed in both. Model TK, however, has flat magnets.

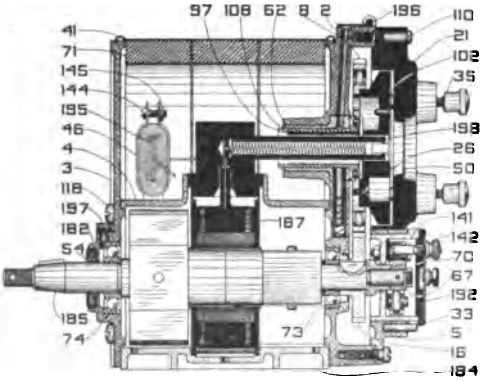


Diagram "J."

Both magnetos are of the inductor type construction, having a stationary winding and revolving rotor. This does away with all moving wires, collector rings, special contacts, etc. and is considered by the manufacturers the simplest form of construction.

K-W Low Tension Magnetos or Alternating Current Generators.

These generators are made for ignition, using a vibrating spark coil and low tension timer, and are made in several models, for either friction or belt drive.

They are also made for tractor and motor boat electric lighting systems, feeding the current direct to the lamps. **These generators will not charge a storage battery,** as they produce alternating current.

Internal Constructon.

This illustration "H" shows the internal construction and extreme simplicity of the K-W low tension magneto, designed on an entirely new principle, and patented by them. Instead of having wires wound longitudinally around a revolving armature, it has stationary spiral winding of copper ribbon, as is shown in the center of illustration "I," and also in illustration "H," which is a view of the inside of a low tension magneto. The rotor changes the direction of magnetic flux through the winding, four times per revolution, and thus produces the electric current. This rotor revolves in two sets of high grade ball bearings and does not rub against or touch any other part on the entire magneto, as all other parts stand still. (See also, page 256.)

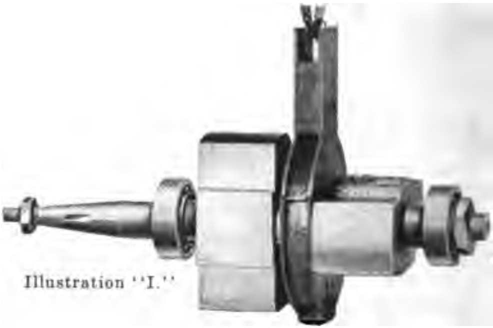


Illustration "I."

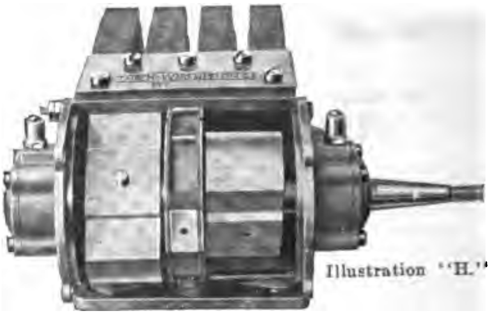
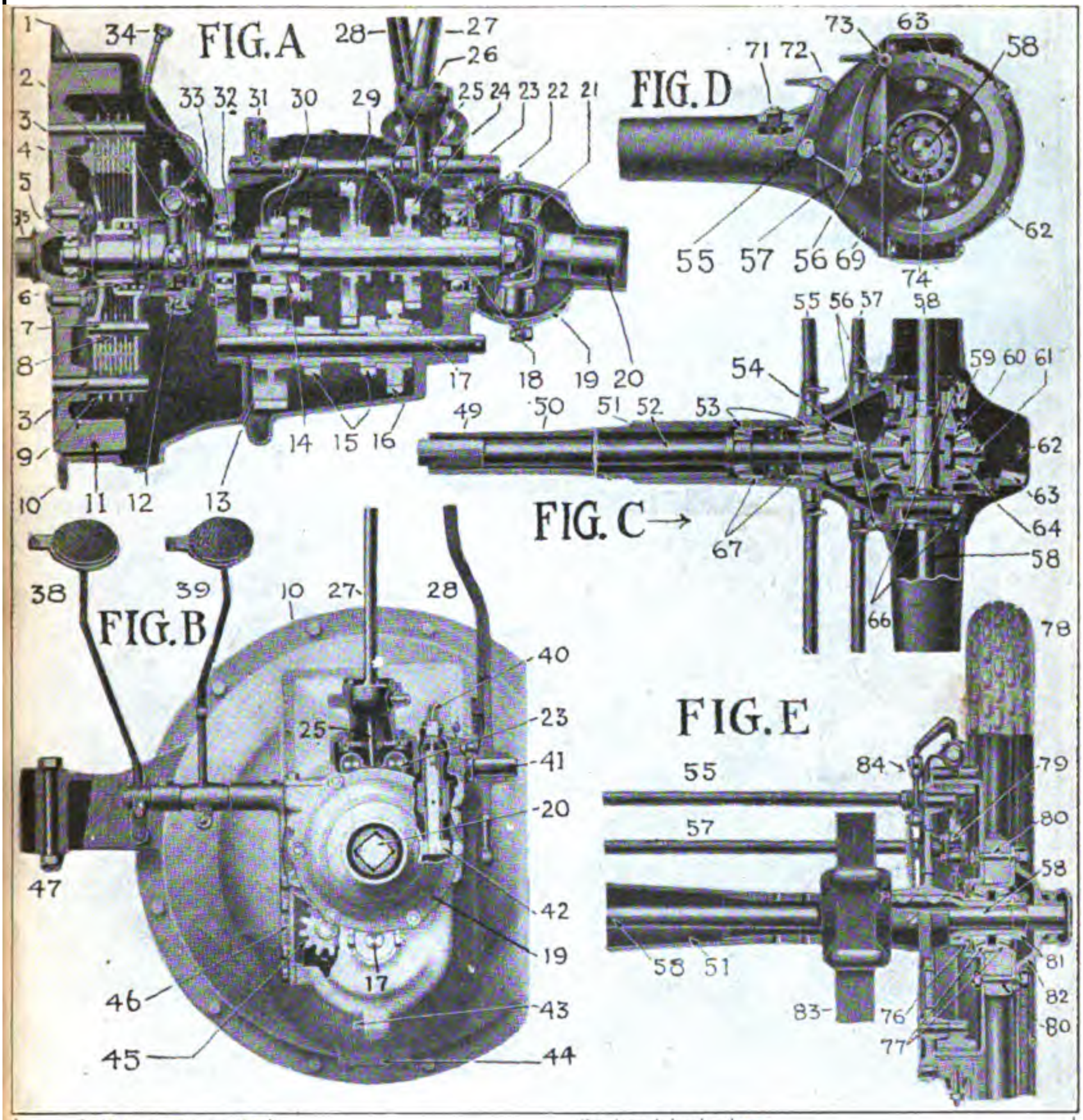


Illustration "H."

The terminals of the winding extend through the top of the pole pieces in which the rotor revolves and are securely connected to the binding posts, which are located at the end of the magneto.

The electrical part is housed in a case, making the magneto practically waterproof. It will stand any amount of spray or rain. Oil it occasionally, and the K-W generator will "stay on the job."

All models of K-W lighting magnetos or generators, in addition to having a special winding suitable for the lights, have the air gap between the rotor and pole pieces so adjusted as to make them automatically self-regulating, due to the impedance of the coil, to a very close degree, so as to take care of the various speeds of the engine.



1	Clutch release fork.	28	Hand brake lever.
2	Clutch pressure plate.	29	Low and reverse sliding gear.
3	Clutch driving disc pin.	30	High speed sliding gear.
4	Clutch spider.	31	Shifting shaft plunger.
5	Clutch shaft front bearing.	32	Clutch shaft.
6	Clutch spring.	33	Clutch shaft rear bearing.
7	Clutch driven disc pin.	34	Clutch release grease tube.
8	Clutch driven disc.	35	End of engine crankshaft.
9	Clutch driving disc.	38	Clutch pedal.
10	Housing, bolts to crankcase.	39	Foot brake pedal.
11	Flywheel.	40	Speedometer drive shaft.
12	Ball bearing clutch release.	41	Hand brake levershaft.
13	Countershaft drive gear.	42	Speedometer drive gear.
14	High speed internal gear.	43	Transmission drain plug.
15	Countershaft low and reverse pinions.	44	Clutch drain plate.
16	Countershaft intermediate gear.	45	Reverse idler pinion.
17	Countershaft.	46	Reverse idler pinion bracket.
18	Sliding gear shaft, or transmission main shaft.	47	Support arm.
19	Universal joint housing.	49	Square end of drive shaft, fits into 20.
20	Universal hollow shaft; square drive shaft (49) fits inside.	50	Torque tube, fits to 19.
21	Universal joint.	51	Rear axle housing.
22	Sliding gear shaft rear bearing.	52	Drive or propeller shaft.
23	Shifting shaft.	53	Drive shaft roller bearings.
24	Intermediate sliding gear.	54	Drive pinion.
25	Shifting shaft yoke.	55	Foot brake operating shaft.
26	Gear shifting fork.	56	Adjusting ring lock screws.
27	Gear shift lever.	57	Hand brake operating shaft.
		58	Rear axle drive shafts.

CHART NO. 420—Parts of The Dodge Drive System.

See Insert No. 1 for top view of Dodge Chassis and pages 369, 370, 733, 924, 411 for Dodge Electric System and Chain Adjustment.

59 Differential roller bearing.
60 Differential bevel gear.
61 Differential cross.
62 Lubricant level plug.
63 Bevel driven gear.
64 Differential bevel pinion.
66 Bearing adjusting rings.
67 Drive shaft bearing adjusting rings.
69 Differential carrier.
71 Adjusting ring lock.
72 Foot brake operating shaft lever.
73 Hand brake operating shaft lever.
74 Differential bearing adjusting ring lock.
76 Grease retainer.
77 Wheel roller bearings.
78 Tire.
79 Brake toggle joint—see page 689.
80 Rear wheel hub bolt.
81 Wheel bearing adj. nut.
82 Rear wheel flange.
83 Spring.
84 Brake mechanism—see also page 689.

Pointers on Adjustment of Dodge Drive System.

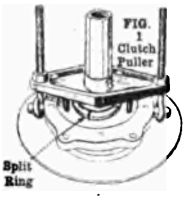
To Adjust Clutch.

See page 666.

*Removal of Clutch and Gear Box.

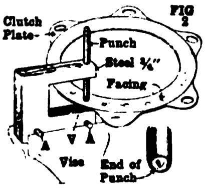
1—Break universal joint; 2—drop emergency brake rod; 3—remove exhaust pipe completely; 4—block up engine at rear, just in front of the bell flywheel housing; 5—remove bolts in rear engine arms (47); 6—remove bolts holding bell housing flange (10) to crankcase; 7—drop foot brake rod; 8—disconnect flexible grease cup tube running from floor board to clutch throw-out; 9—slide unit to rear and lift out.

Disassembly of Clutch.



1—Remove two lock screws in clutch throw-out yoke (visible from clutch hand hole); 2—remove two nuts on clutch throw-out yoke; 3—remove clutch pedal (38) from its shaft and loosen brake pedal (39); 4—drive out clutch shaft (32) to the left; 5—lift out clutch unit; 6—apply clutch puller, fig. 1, to complete clutch disassembly. The puller consists of a cross member with a bolt terminating in a hook perpendicularly placed at each extremity. The hooks engage pins on the clutch; 7—draw down on puller nuts until the clutch spring is sufficiently compressed so that the split locking ring may be withdrawn; 8—remove split locking ring; 9—ease up on puller nuts, and then remove clutch spring; 10—clutch plates may now be taken apart.

To Replace Clutch.



See fig. 2. The facings come already cut and drilled so it is merely a matter of riveting a new facing in place on the driving discs 9, fig. A, page 931. A tool especially designed for this purpose is shown in fig. 2. The punch is made of a valve stem, hardened. In putting in the hollow rivets, half of them should face one way and alternate ones in opposite direction. This tool may also be used to rivet brake linings, page 689.

Noisy Rear Axle.

When there is a singing or humming noise constantly in rear axle, with the humming increasing with speed, and the rear axle mesh seems stiff when clutch is thrown out, it is usually due to the adjustment of the drive pinion (54) to the driven bevel gear (63) being meshed **too tight.**

When there is noise and back-lash, which is more noticeable when clutch is "thrown-out," and there seems to be a loose, jerky motion in rear, when clutch is "thrown-out," it is probably due to gears 54 and 63 **not meshing tight enough.**

Remedy: First see if there is oil on teeth of gears by taking filler plug out and sticking your finger on gear. Often times heavy grease will not throw all way 'round.

Adjustment: Ordinarily the adjustment of drive pinion (54) is sufficient. If not, then driven bevel gear (63) must also be adjusted.

Note. On other makes of cars having "helical" gears the same rules apply.

To Adjust Drive Pinion.

The whole drive shaft 52, fig. C, page 931, can be adjusted endwise to obtain exact position of the driving pinion (54) which is rigidly attached to it, in relation to the driven bevel gear (63) bolted to the differential. Two adjusting rings (67), fitted against the two Timken bearings (53), can be screwed forward or backward to obtain the proper position of the bevel driving pinion (54). These rings can be reached by removing the ring lock (71, fig. D). All that need be done is to back off one adjusting ring (67, fig. C), and screw the other one ahead, in whichever direction it is desired to move the bevel driving pinion (54). Be sure that each of them is holding its bearing rigidly before replacing lock (71).

Adjustment of Bevel Driven Gear.

To test if the bevel gear (63) is running quiet, jack up the rear axle and run the engine with the gears, in direct drive about 20 m. p. h. as indicated by speedometer.

After adjusting the bevel driving pinion (54) as explained above, if still noisy, then remove rear axle cover plate and the two adjusting ring lock screws (56) and readjust bevel driven gear (63) to the new position of pinion.

The large bevel driven gear (63) can be moved either to the right or to the left in order to insure its quiet engagement with driving pinion (54), by operating the two bearing adjusting rings (66, fig. C, page 931) in similar manner as those used in adjusting the drive pinion. After adjusting, they are locked in place by the adjusting ring lock screws, (56, fig. C and D, page 931).

Removal of Rear Axle Shafts.

The rear axle is of the full floating type, permitting the removal of the drive shaft (58, figs. C and E, page 931), without jacking up the car.

To remove rear axle shafts (58) and flanges (82), simply unscrew the nuts on bolts 80, which hold the flanges to hub of wheel and remove them together with the axle shafts. If one axle shaft should stick, remove one on opposite side and drive or push other one out wth a long rod.

Lubrication of rear axle: use 5 pints, if empty, of gear lubricant, or enough to fill rear axle up to level of lower plug, 62, figs. C and D, page 931. If grease leaks out rear wheels, housing is too full.

To Disassemble Differential.

1—Remove axle shafts 58; 2—remove inspection plate; 3—take caps off bearings and lift out; 4—remove cotter pins and nuts on the 4 studs which hold differential unit together and disassemble.

FIG. 4

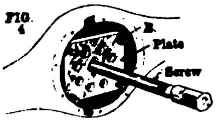


Fig. 4: To remove drive pinion (54), a plate is bolted to the 4 studs and pressure applied to shaft by screw.

FIG 5

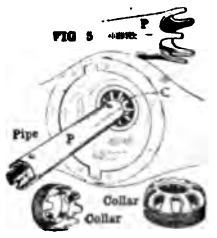


Fig. 5: To remove front bearing adj. collar C, turn to left with a screw driver. A special wrench for this purpose can be made of a piece of pipe P.

Fig. 3: Puller for front of universal joint.

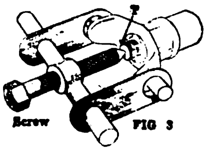


FIG 3

Fig. 6: Drag link cap is filed to give adjustment.

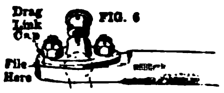


FIG. 6

CHART NO. 421—Dodge Drive System—Continued.

*See also, pages 666, 670 and Insert No. 1. See page 689 for Dodge Brake Adjustment. (Motor World.)

LIBERTY ENGINE SUPPLEMENT.

Brief History.

At the declaration of war, Mr. H. E. Coffin, and soon thereafter, Mr. E. A. Deeds, were called upon to organize the production of aviation equipment.

J. G. Vincent, Chief Engineer of Packard Motor Car Co. and E. J. Hall of the Hall-Scott Co., of Berkeley, Calif., were called into conference at Washington, May, 1917. On May 29th, these two men started the design of an 8 cylinder aviation engine to develop approximately 200 h. p. and a 12 cylinder engine to develop 300 h. p. The first engine, an 8 cylinder was delivered to Bureau of Standards, Washington, July 4, 1917, and ran successfully.

The Engine Production Department, a portion of the Division of the Signal Corps was created in Aug., 1917, with Lieut. H. H. Emmons in charge as Chief Engineer of Engine Production Department.

The horse power of engine was increased to 440 h. p. and in spite of many difficulties, more than 15,000 engines were produced by Nov. 29, 1918, or within 18 months after work began. Certainly a marvelous accomplishment.

Oiling System.

The oil supply for the Liberty engine is carried in a reservoir which is cooled. This reservoir is mounted somewhere in the vicinity of the engine and from it oil is led to the connection on the right side of the oil pump body, which is marked "oil in."

There are two oil pumps; a delivery pump and an oil return pump.

Oil return pump: immediately above the oil delivery pump is located the "oil return pump" consisting of three gears, and driven by the same shaft as the delivery pump. The function of this oil return pump is to draw the excess oil out of the crank case and return it to the oil reservoir. One half of this pump draws oil from the oil sump at the propeller end of the crankcase and the other half draws oil from the sump at the distributor end of crankcase. Both halves of the pump deliver oil to the connection on the left side of the oil pump body marked "oil out," from which point it returns to the oil reservoir.

The oil delivery pump takes the oil and delivers it under pressure to a distributor pipe (C) running the entire length of the crankcase.

There is a pressure regulating valve between the pump and the distributing pipe which holds the pressure so that it does not exceed 50 lb. per sq. in.

The oil gauge pressure, after about 3 min. running at 600 to 800 r. p. m. should show about 5 lbs. pressure, and at 1600 r. p. m. up to 30 lbs.

From the distributor pipe, there are pipes (P) leading to the main crankshaft bushings. The crankshaft is hollow, and in the center of each main bearing there is a radial hole drilled through the shaft into the hollow center. A passage leads from each hollow main bearing to the adjacent crankpin, which is also hollow. A radial hole is drilled through each crankpin and carries the oil out on the surface of the pin.

There are oil grooves and passages in the connecting rod bushings to insure proper lubrication for both the forked and plain connecting rods.

The oil spray thrown off by centrifugal force from the ends of the connecting rods lubricate the **piston pins and cylinder walls.**

A part of the oil conducted to the crankshaft main bearing at the propeller end of the engine goes through a passage around this bearing and up through pipe leads F and E, to the propeller end of the camshaft housings. From the end of the camshaft housing it is led around the end of the camshaft bearing through a passage drilled diametrically through the bearing midway of its length.

Once every revolution of the camshaft, a hole drilled through the camshaft into its hollow center **registers** with the oil passage through the bearing.

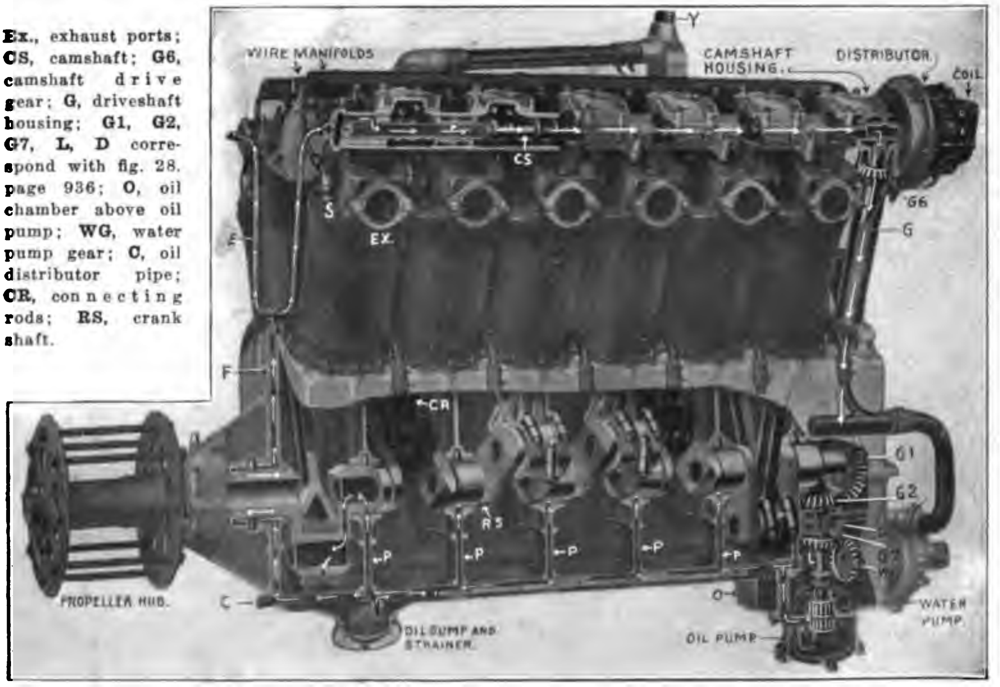
Thus once every revolution of the camshaft a small quantity of oil is forced into the hollow camshaft.

The oil is led through the camshaft and out through holes drilled in it to each camshaft bearing.

The excess works out of the ends of these bearings and collects in small reservoirs to a depth of about ¼ in. The cams, in revolving, dip into this oil and splash it over the cam rollers.

The excess oil eventually finds is way to the gear end of the camshaft housings, over the gears and down the drive shaft housing into oil chamber (O) just above the oil pump.

The excess oil thrown off in the crankcase by the connecting rods collects in this same chamber when the engine is inclined so that the propeller end is high. If the propeller end of the engine is low, this oil collects in the oil sump or chamber at the propeller end of the crankcase.



Ex., exhaust ports; **CS**, camshaft; **G6**, camshaft drive gear; **G**, driveshaft housing; **G1**, **G2**, **G7**, **L**, **D** correspond with fig. 28, page 936; **O**, oil chamber above oil pump; **WG**, water pump gear; **C**, oil distributor pipe; **CR**, connecting rods; **RS**, crank shaft.

General Construction.

The Liberty engine used in the De Haviland and other land planes and many seaplanes is a twelve-cylinder V-type with overhead valves and overhead camshaft. **It weighs** approximately 890 lbs., and the **horsepower** ranges between 350 and 400 in the Army type with the high compression pistons and 320 to 340 in the Navy type with low compression pistons (fig. 28).

The rated fuel consumption is 0.54 lb. a horsepower, or 36 gal. an hour with wide open throttle at 1700 r.p.m. Under service conditions about 30 gal. an hour is fairly representative consumption.

The oil consumption is 0.03 lb. a horsepower-hour, or 1½ gal. an hour with wide open throttle at 1700 r.p.m.

The horizontal flying speed of the engine is 1700 r.p.m., and the ground speed is 1600 to 1625 r.p.m.

Cylinders.

Cylinders: The design is followed after the practice used in the German Mercedes (page 916), English Rolls-Royce, French Lorraine-Deitrich, and Italian Fraschini, before the war and during the war.

The cylinders are made of drawn steel inner shells surrounded by pressed steel water jackets welded to the cylinders and at their own seam. Each cylinder has one inlet and one exhaust valve and two spark plugs.

Angle between cylinders: In the Liberty the included angle between the cylinders is 45°; in all other existing 12-cylinder engines it is 60°. This feature is new with the Liberty engine, and was adopted for the purpose of bringing each row of cylinders nearer the vertical and closer together, so as to save width and head resistance. By the narrow angle greater strength is given to the crank case and vibration is reduced.

A disadvantage of this angle, if used for automobile work would result in uneven firing impulses—which would be noticeable at low speeds, as the spark occurs close together, 22½°, and then far apart 37½° of distributor brush rotation, similar to explanation on page 918, except the Delco battery system is used on the Liberty instead of a magneto as explained on page 918.

With the airplane engine however, where the speed is usually high and constant, the uneven impulse is not noticeable.

The bore is 5 in. and stroke is 7 in., same as on the Hall-Scott, A-5 and A-7 engine, page 912, and as used on the Hall-Scott 12 cyl. engine. **Piston displacement** is 1649.34 cu. in.

An engine in all respects identical with the Liberty airplane engine, but having cast iron cylinders is used in Tanks.

Pistons.

The pistons are of aluminum, and are of the Hall-Scott design, page 913.

There are two designs of pistons used, one for the Army and one for the Navy. (see fig. 28, page 936.)

The Army-type pistons have a crowned head which gives an 18 per cent compression space.

****The Navy-type pistons** have a flat head which gives a 20.5% compression space.

The pistons are 5 in. long and have three rings of the eccentric type, all at the top of the piston. These piston rings are assembled with a gap between the ends of the rings not less than .025 in. The pistons of the engine weigh 3 lb. 3 oz.

Piston Pin

is a seamless steel tube, the tube being a drive fit into the bosses on the aluminum piston. Tube is 1¼-in. outside diameter and surrounded by a bronze bushing, upon which upper end of connecting rod bears.

Crankshaft.

The design follows the standard 12-cylinder practice, except as to oiling—see page 933 and below.

Crankshaft is a drop-forged seven-bearing crankshaft 2⅝ in. in diameter, the longer being at the propeller end.

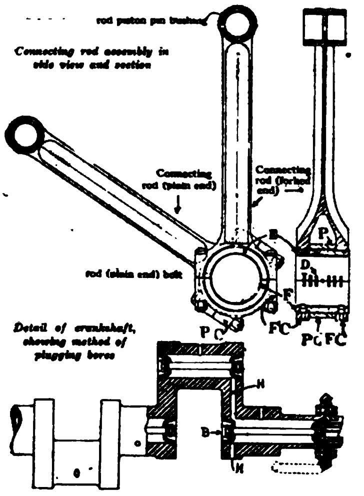
The shaft carries a propeller-hub at its forward end and at the rear end carries a bevel gear for driving the valve mechanism.

A double row thrust bearing at the propeller hub end of the crankshaft takes the end thrust on the shaft.

The shaft is drilled for oil passage, the openings being drilled through the crank cheeks through the crankpins.

Connecting Rods.

The forked or straddle-type connecting rods of I-beam type are used. This type of connecting rod was first used by the French De Dion car and on the Cadillac in this country. The length is 12 inches between centers. Both crankshaft and connecting rods are made of chrome nickel steel.


rod piston pin bushing
Connecting rod assembly in side view and section
Connecting rod (plain end)
Connecting rod (forked end)
rod (plain end) bolt
B
P
D
F
P C
FC
PC FC
Detail of crankshaft, showing method of plugging bores
H
B
H

Note, lower part of the plain end connecting rod is placed between the forks of the forked end rod. P—shows section of lower end of plain rod

—continued on page 935.

***Engines required for different classes of work were:** (1) The Elementary Training Planes; (2) For Advanced Training Planes; (3) For Combat Planes. For 1, Curtis OX, 90 h. p. engine, page 921, and Hall Scott A-7A, 100 h. p. engine, page 913 were used. For (2), the Gnome 110 h. p. engine, page 910, made by The General Vehicle Co., Long Island, N. Y. and the Le Rhone (similar), of 80 h. p., made by the Union Switch and Signal Co., Swissvale, Pa., and the Hispano-Suiza, 150 h. p., page 918, by the Wright-Martin Co., New Brunswick, N. J. For (3), the Liberty Engine. It was estimated that 22,500 would be required for the Army and Navy.

**See foot note, page 936.

over the bearing bushing E, which is the upper half of bearing bushing, and F, is the lower half. The plain rod has one cap (PC) and the forked rod, two caps (FC). The left rods are forked and the right, plain.

The clearance between crank pin and lower connecting rod bushing varies from .003 to .004″.

Clearance between plain rod and back of bushing .005″.

The bushing carried by forked rod should have from .010″ to .020″ side play on the crank pin.

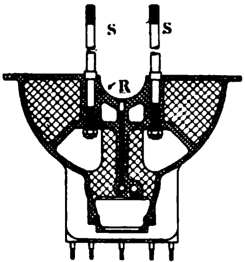
The plain end rod should have from .004″ to .008″ side play in the forked rod.

Crankcase.

The crankcase is in two pieces, both of which are aluminum castings.

The crankshaft bearings are on a line with the split in the crankcase, the lower halves of the crankshaft bearings being held in the lower half of the crankcase and the upper halves in the upper half of the crankcase.

The two halves are tied together by long bolts or studs (S), which pass through the upper half of crankcase, through bosses, the nuts being at the top of the upper half of the case. This gives an accessible construction which is at the same time rigid.



Cross section through lower half of crankcase.

A careful joint is made between the two halves of the crankcase in order to secure the desired alignment at the main bearings, the joint being lapped.

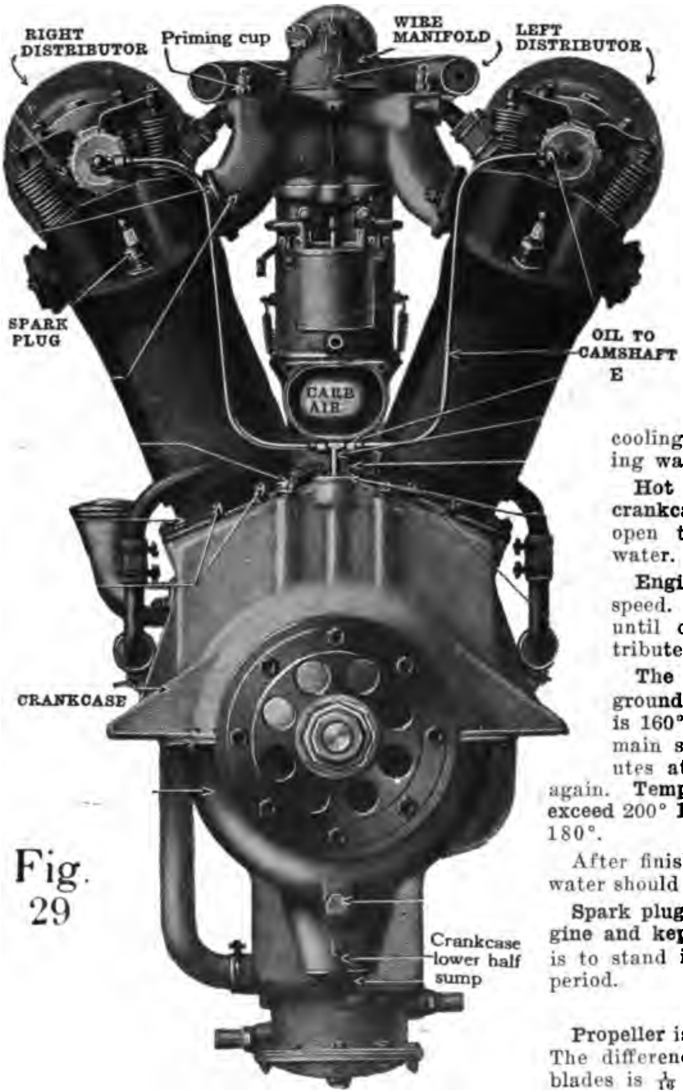


Fig. 29

Propeller end view of Liberty "12" Engine.

Cooling System.

Cooling water is circulated through the Liberty engine by a centrifugal pump running at one and a half times engine speed. **The capacity of this pump** is 100 gal. a minute at 1700 r.p.m. The cooling system from the pump inlet to and including the water outlet header will hold 5½ gal. of water or 46 pounds.

Cold Weather Instructions.

Anti-freezing preparations are not used. The cooling system is filled with boiling water.

Hot lubricating oil is put into crankcase. Oil can be heated in an open top container set in boiling water.

Engine is primed to start, at slow speed. Engine is then run on ground until oil has been thoroughly distributed.

The plane is not taken from the ground until the water temperature is 160° Fah. Engine should not remain stationary more than 10 minutes at a time, as it will get cold again. **Temperature of water should not** exceed 200° **Fah.** and should average about 180°.

After finishing a test flight, all oil and water should be drained before engine cools.

Spark plugs **should be removed from engine and kept in a warm place,** if engine is to stand idle over night or for a long period.

Propeller.

Propeller is 9 feet di.; blade 9 in. width. The difference in pitch between the two blades is $\frac{1}{16}$ inch in 9 inches. The Hall-Scott **propeller hub,** page 915 was adopted.

CHART NO. 420—Crank Case and Cooling System.

Valves and Camshafts.

Valves.

The valves are mounted in the heads of the cylinders and are inclined at an angle of 15 deg. to the center line of the cylinder, so that the angle made by the center lines of the two halves is 30 deg.

The valves are the standard mushroom type with 45-deg. seat. The cylinder heads are bushed for the valves and the valve springs are of the double concentric type.

The intake manifold passes between the two rows of cylinders, and the carbureters in most of the installations are mounted in the V.

The entire valve drive is housed above the cylinders and can be readily removed without tearing down the engine.

The valves are operated from the camshaft by roller cam followers, which actuate the rocker shaft and in turn the valve rocker arm or lever. See page 938, fig. 67, also pages 914, 913, 912 which is a similar principle.

To adjust valve clearance; turn tappet screw, see fig. 67, page 938.

Cam-Shaft Drive.

The camshaft drive was copied almost entirely from the Hall-Scott motor, page 914. In fact, several of the gears used in the first sample engines were supplied by the Hall-Scott Motor Car Company. This type of drive is used by Mercedes, Hispano - Suiza, and others.

By referring to fig. 28, the drive system can be seen.

Drive-Gear System.

G1, main drive gear on end of crankshaft; **G2,** drive gear for lower oil and water pump shaft; **D,** bearing assembly; **G7,** drive gear for water pump; **N,** oil plug; **L,** oil pump shaft (runs 1½ times engine speed); **G3,** driven gear for upper shaft; **G4,** drive gear for the two inclined shafts (through G5), which drives the right and left overhead camshaft.

The inclined shafts revolve 1½ times engine speed; **G6,** gear (one on each inclined shaft) to drive camshaft; **camshaft** revolves ½ engine speed; **distributor rotor** or brush, is driven from **camshaft,** at camshaft speed.

Tachometer **drive and gun synchronizer:** Provision is made for mounting a mechanically driven air pump on the distributor end of the engine crankcase and driving it by means of a splined shaft fitting into the crankshaft gear. An extension of this shaft carries a double adjustable cam designed to operate a machine gun. The over-all length of the unit is 6 in. **The tachometer** is driven from generator shaft.

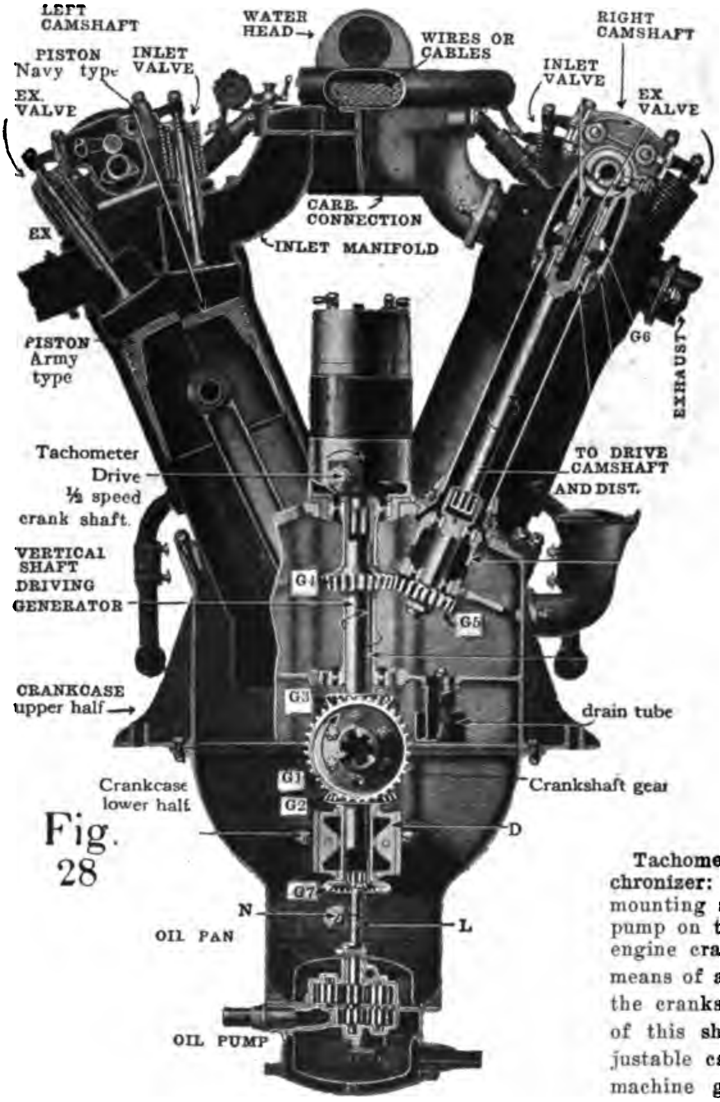


Fig. 28

Transverse section, from distributor end, showing how the oil and water pump, generator and camshaft are driven, and valve action.

CHART NO. 421—Valves, Camshafts and Drive Gear System.

The Navy type usually works at low altitudes and Army type at high altitudes, hence reason for low and high compression pistons.

Valve Pointers.

One method for testing gas tightness of a valve: This can best be done by inverting the cylinder with the valves in place and pouring a small quantity of gasoline in the cylinder. Watch for seepage around the valve. If the valves show any leak, they should be carefully ground in. The cylinder, for this operation, should be held in position by means of the flange at the bottom.

Valves should not be ground any oftener than is absolutely necessary; and then only enough to "clean up" the seat. If a valve is pitted or warped to such an extent that it is necessary to grind it heavily, care should be taken that any ridge or shoulder formed on the edge of the valve seat be dressed down with a fine mill file. The abrasive should be carefully washed off the valve, the seat and the inside of the cylinder. Test seating of valve with Prussian blue.

The exhaust valve spring exerts a pressure of 45 lbs. when compressed to a length of 2¼ in. The intake valve spring exerts a pressure of 23½ lbs. when compressed to a length of 2¼ in.

Piston Pointers.

Examine piston for scores. It is very likely that the pistons will show scratches which were caused during the first run in of the engine. It is difficult to draw a line of distinction between what is termed a scratch and a score. A piston should not be discarded unless the scores extend past the piston rings and seem to be of recent origin.

Examine piston for even bearing on its outside surface. If any piston shows excessive wear on one side at the bottom and not at the top, it is an indication that the connecting rod is **twisted or** bent. This rod should be straightened up before assembling.

Piston Rings.

Examine piston rings for even bearing on the outside surfaces. The ring should be a free fit in the grooves and should not be so loose that any shake is noticeable.

Inspect condition of ring grooves through the ring gap as to carbon deposit. If the carbon is soft and not of great amount it may be wiped out with a soft rag over a splinter of wood inserted through the gap in the ring. If the amount of carbon is excessive and caked hard, the ring should be taken off.

Ring grooves should be wiped out with a soft cloth moistened with gasoline, and any carbon caked in these grooves may be scraped out with a piece of wood.

It is preferable to put back the old rings if the wear has not been too excessive, than to fit new rings which have not been run in.

The gap between the ends of the ring should not be less than .025 in. when the ring is fitted in the cylinder.

Connecting Rod Bearings.

If the bearing has been damaged or shows wear to such an extent that it is advisable to replace it, the new bushings should first be fitted in the forked end rod. Be sure that the bushing seats properly in the rod and that the dowel does not hold it away at any point.

The caps of the forked end rod should be put in place and drawn up tightly.

Examine the joints between the cap and the rod and between the two halves of the bushings. Caps and bushings should bear equally hard at the joints.

The **bushing should then be scraped to** a **free fit** .003 in. to .004 in. larger than the crank-pin.

The **ends of the bushing** should be dressed off with a fine mill file and a sufficient amount removed to permit from .010 in. to .020 in. **side** play. Touch up the **radius** at each end of the bushing with a scraper until it clears the fillet of the crank pin. Test this point by coating the crank pin and each fillet lightly with red lead or Prussian blue.

After fifty hours running, engine should undergo a thorough inspection.

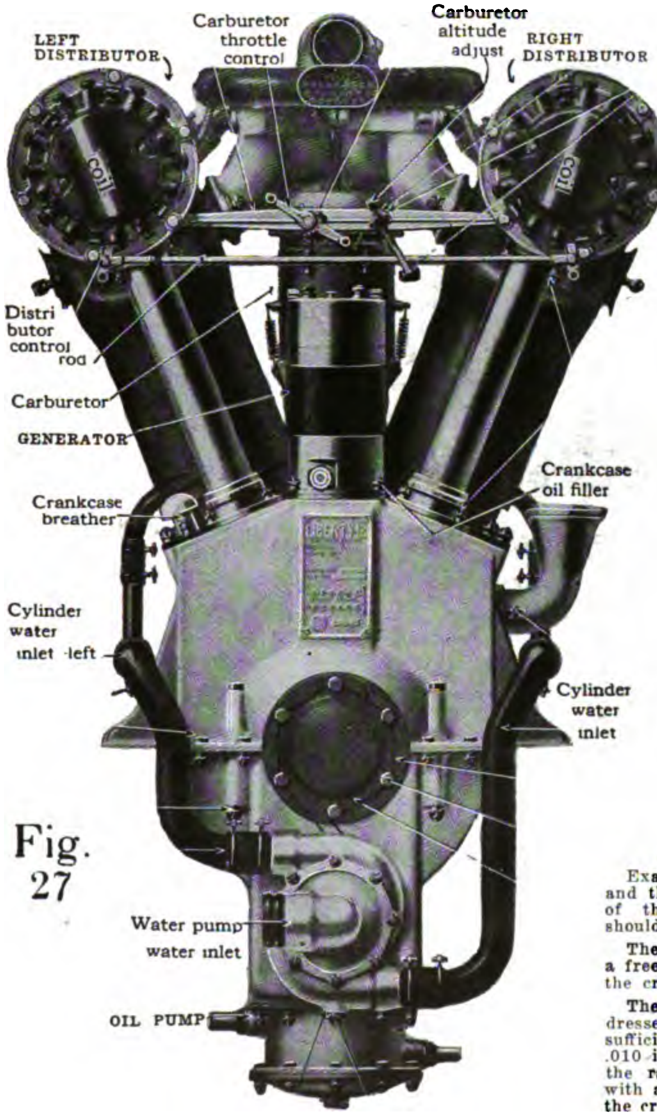


Fig. 27

Distributor or rear end view of Liberty "12" engine.

Note—the high tension ignition coils are an integral unit of each distributor, being placed on the front of same. Note all controls are at this end of engine.

CHART NO. 422—Distributor End, Showing Distributors, Generator, Water and Oil Pump. Practical Pointers.

Firing Order and Valve Timing.

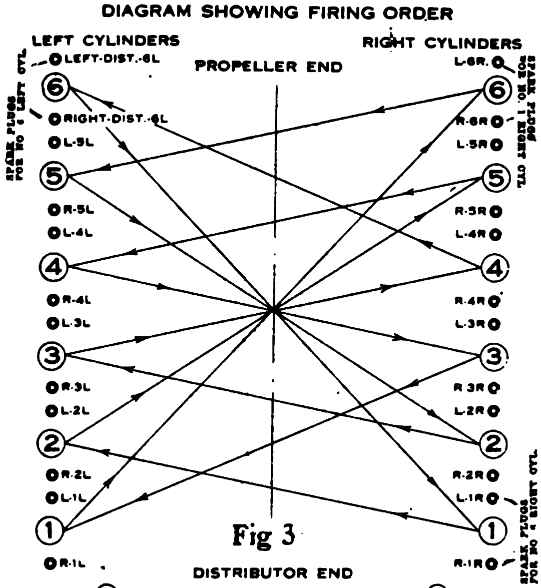


Fig 3

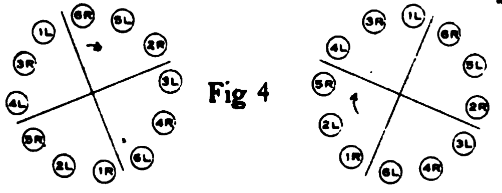


Fig 4

LEFT DISTRIBUTOR   RIGHT DISTRIBUTOR

Order of firing—Standing at the distributor end of the engine and looking toward the propeller, the groups of cylinders are designated as "Left" and "Right" respectively and are numbered 1, 2, 3, 4, 5 and 6 beginning at the distributor end The order of firing is as follows

1	2	3	4	5	6	7	8	9	10	11	12
1L	6R	5L	2R	3L	4R	6L	1R	2L	5R	4L	3R

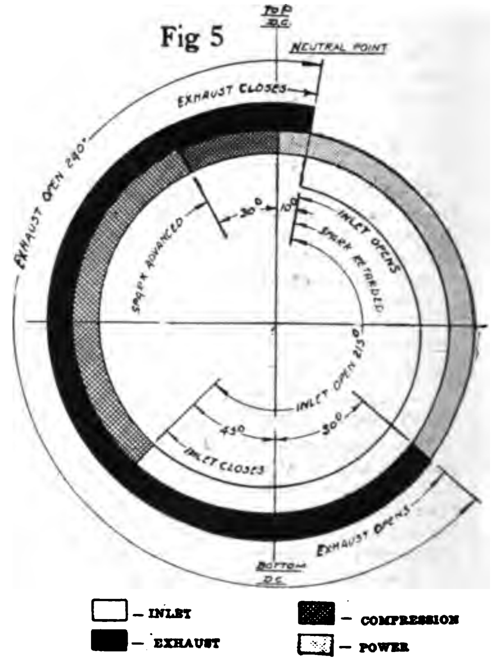


Fig 5

Valve timing: Inlet opens 10° after top d. c., closes 45° after bottom d. c., exhaust opens 50° before bottom and closes 10° after top. **Note if spark is full advanced the spark will occur 30° before top d. c., on compression stroke.**

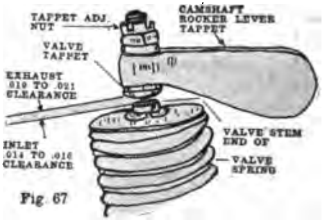

TAPPET ADJ. NUT
VALVE TAPPET
EXHAUST .019 TO .021 CLEARANCE
INLET .014 TO .016 CLEARANCE
CAMSHAFT ROCKER LEVER TAPPET
VALVE STEM END OF
VALVE SPRING

Fig 67

Electric Wiring and Ignition System.

Electric wiring: For low tension work, No. 14 stranded cable for distance of 10 feet or less, or No. 10 for distance up to 25 feet, well insulated with rubber and braid. Wires taped and shellaced where clipped to fuselage. See fig. 7, wiring diagram. **Single wire grounded return** (G), system is used.

Spark control advance and retard at distributor is, 10 degrees after dead center "retarded," and 80 degrees before dead center "advanced," see fig. 5. above.

Contact breaker (timer) gap when breaker is wide open, should be .010 to .013 of an inch.

Spark plug gap; .015 to .018 of an inch. Defects in all spark plugs are most apparent when the plugs are hot.

Timing: When engine is set on firing point of No. 1L cylinder, in other words, with No. 1L crank set 10 degrees past top of "compression" dead center, the carbon brush in the end of the distributor rotor should bear on the brass contact marked 1L on distributor head.

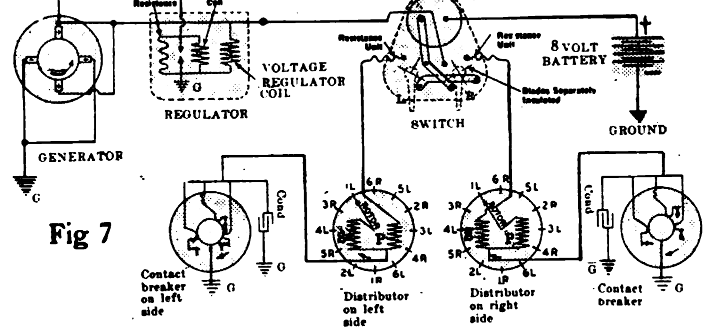


Fig 7

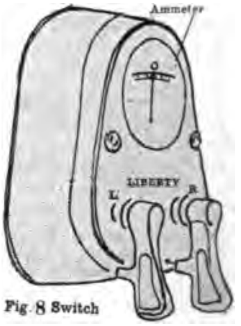


Fig 8 Switch

CHART NO. 423—Firing Order; Valve Timing. Electric System.

Electric System.

Ignition.

The ignition system (Delco) used on the Liberty twelve is the battery type with two independent breaker and distributor mechanisms, mounted on the ends of the camshafts, identical in every respect and each one firing all twelve cylinders.

These distributors are supplied with electrical energy from two sources: For starting and idling speeds up to 650 r.p.m. current is drawn from the specially constructed **four-cell storage battery** which has sufficient capacity to ignite the engine at full speed for 3 hr. and is so constructed that it will function properly upside down. (8 volt, 11 ampere-hour capacity).

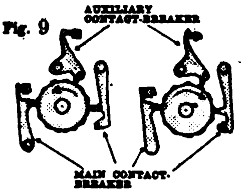
The generator builds up so that it takes up the load at 650 r.p.m.

Two main contact-breakers connected in parallel are located in each distributor box and the two circuit breakers are timed to operate simultaneously. The two contact-breakers are provided in duplicate as a precautionary measure. **The breaker cams** have 12 lobes.

Auxiliary circuit or contact-breaker is to prevent the production of a spark when the engine is turned backward or "rocked." This auxiliary breaker figs. 9 and 7, is connected in parallel with the other two through a resistance unit which reduces the amount of current flowing through it. The breaker is so timed that it opens slightly **before** the other two when the engine is turned in a forward direction. The opening of the main breakers then results in the production of a spark.

When the engine is turned in a **backward** direction the two main breakers open first and no spark is produced due to the fact that the current continues to flow through the coil through the auxiliary breaker but in diminished quantity due to the resistance unit. By the time the circuit is opened at the auxiliary breaker the intensity of the magnetic field of the coil has weakened to such an extent that no spark is produced.

Fig. 9



A coil is incorporated in the cover of each distributor head—see fig. 27, page 937.

Generator.

In addition to the battery, a positively driven generator, mounted to rear of engine, figs. 27 and 28, is provided, so geared that it runs at 1½ times crankshaft speed. It is a 4 pole shunt wound machine.

As stated above, electrical energy for starting and idling speeds is supplied by the battery. As the engine speed is increased, the generator "builds up" and its output grows greater until, at about 650 r.p.m. the generator voltage equals that of the battery.

The maximum generator output exceeds the requirements for ignition so that, at speeds above 650 r.p.m. the direction of flow of current is reversed and the excess output of the generator goes to recharge the battery.

Regulation: The generator is controlled by a "voltage regulator," mounted on cowl of plane, and consists of an iron core on which are wound three coils, the connections of which are shown in fig. 7. The regulator prevents the output exceeding a pre-determined figure. In view of this fact, the generator will supply **current for ignition** indefinitely, without the battery, so long as the engine speed is not allowed to drop below 500 r.p.m. It is not possible to crank the engine fast enough to start it on the generator, however.

Switch.

A duplex ignition switch, mounted on the cowl of plane, fig. 8, is provided which will permit either one or both distributors being turned "on." This switch is so constructed that either set of ignition alone can be used without connecting in the generator.

In starting, only one side should be used as, with both switches "on," the generator is connected to the battery. Under these conditions the discharge from the battery through the generator before the engine is started would be an excessive drain on the battery. It is essential that both switches be "on" at all **flying speeds.**

When operating at a speed under 650 r. p. m., only one switch should be used, as with both switches on, the generator is in the line and working as a motor. Result is, with both switches on, the pull on battery is about 12 amperes. With one switch on, the draw is 4 amperes, which is the ignition load.

Idling at 650 r. p. m. for an hour, with both switches on will discharge battery.

The ignition switch has an ammeter incorporated in it and this ammeter should be watched occasionally as it indicates the amount of current flowing to or from the storage battery.

If the ammeter shows a discharge at any speed above 650 to 700 r.p.m. with both switches "on" it is an indication that something is wrong with the generator circuit and that all electrical energy is being supplied by the storage battery.

If the ammeter stands at zero under the same conditions, it indicates that the storage battery is not receiving a charge, but that the ignition is being carried by the generator.

There are two ignition resistance units mounted on the back of the ignition switch, see fig. 7. They are for the purpose explained on page 378.

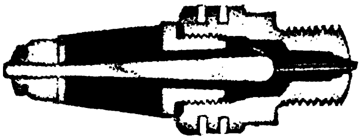
Storage Battery.

Storage battery is charged at .7 amperes for 70 hours if discharged. It is an 8 volt 4 cell battery.

Spark Plug.

There are two spark plugs per cylinder to the Liberty 12.

One airplane type of spark plug (Splitdorf) is illustrated below.



They are subjected to pressure of 90-110 lbs. The gap distance is .015 to .018. The life of a plug of this type is 25 to 100 hours.

The parts of the Splitdorf plug is as follows; brass terminal, mica washers, lateral wound mica, steel center rod, 98% pure nickel electrode point, carbon steel from brass terminal to electrode and carbon steel shell.

The AC Titan, one-piece porcelain spark plug is used on the Liberty 12-cylinder engine.

Carburetion.

Two Zenith duplex carburetors, similar to principle explained on page 182 and 181, are used. This is equivalent to four single carburetors, each one supplying three cylinders of the engine.

Each duplex carburetor consists of a single float chamber and a single air inlet joined to two separate and distinct spray nozzles, venturi and idling devices.

Each of the two barrels of each carburetor is fitted with a throttle valve of the butterfly type. The two pairs of throttles are operated simultaneously by a shaft, provided with an adjustment at each end by which the pairs may be synchronized.

Each duplex carburetor is fitted with an altitude adjustment.

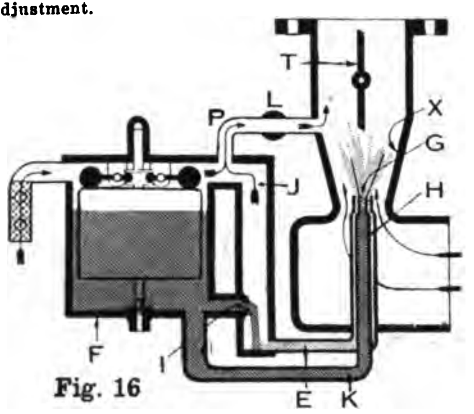


Fig. 16

An altitude adjustment is incorporated in this Zenith airplane type carburetor. The purpose of which is to adjust the gasoline supply to the changed conditions met with at higher altitudes.

If a carburetor is adjusted to deliver a properly proportioned mixture at sea level, it will supply an increasingly "rich" one as the machine mounts to higher altitudes. due to the fact that the air is lighter and less dense—as explained on page 920.

The principle of the altitude adjustment, shown in fig. 16, is as follows: The float chamber is open to the air through two screened air inlets.

The well (J) is in open communication at its top with the float chamber.

A passage (P) is provided from the float chamber to the carbureting chamber below the throttle valve; this passage is fitted with a stop cock (L), which is manually operated from the pilot's seat.

Under normal conditions, that is, on the ground, the stop cock (L) should be closed and the gasoline in the float chamber will be subjected to atmospheric pressure through the screened air inlets.

When the engine is running, the partial vacuum produced in the throat or choke (X) will draw the gasoline out of the nozzle (G) and (H) in proper proportions.

At an altitude of about 6000 feet, the aviator will begin to open the valve (L) thus drawing **air from the float chamber** and establishing therein a partial **vacuum,** which depends on the degree of opening of stop cock (L); this partial vacuum will **impede** the flow of gasoline through the jets, and **the** mixture will be made more lean.

The altitude valve should be opened as far as possible consistent with obtaining the greatest number of r. p. m. of the engine.

The float level is set so that gasoline level is ⅛" below main cap jets.

Gasoline System.

The air pressure feed is used from the **main gasoline tank.** The initial pressure (3 lbs.) is obtained from hand pump (fig. 6). After engine is running the air pressure is obtained from the power air pump on engine.

The auxiliary gravity feed tank, located overhead is filled by pressure from the main tank. See fig. 6, for further details.

The engine-driven air pump with its regulator, is designed to hold the pressure on the gasoline tank to approximately three pounds. In order to determine whether or not the pump is functioning properly, screw **down** the pressure regulator adjusting screw. This should cause the pressure in tank to rise if the pump is operating as it should. Now screw the regulator adjustment up until the pressure is held steadily at three to four pounds.

Gasoline **recommended:** Specific gravity; 58 to 65 Baume; initial boiling point, 102 degrees Fah., not higher than 120 degs. Fah. Final boiling point 350 degs. Fah.

Fuel consumption is .54 pounds per horse power hour, or 36 gallons per hour with wide open throttle at 1700 r. p. m.

Gasoline pipe is annealed copper tubing ⅜" inside di. from tank to T, between carburetors. From this T to each carburetor, $\frac{5}{32}$" di.

Air pressure pipe is $\frac{3}{16}$" inside di., copper tubing.

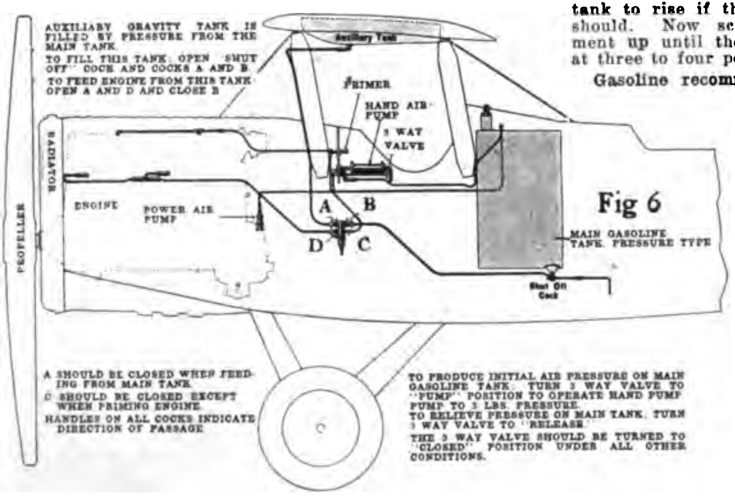


Fig 6

AUXILIARY GRAVITY TANK IS FILLED BY PRESSURE FROM THE MAIN TANK.
TO FILL THIS TANK: OPEN "SHUT OFF" COCK AND COCKS A AND B.
TO FEED ENGINE FROM THIS TANK OPEN A AND D AND CLOSE B

A SHOULD BE CLOSED WHEN FEEDING FROM MAIN TANK.
C SHOULD BE CLOSED EXCEPT WHEN PRIMING ENGINE.
HANDLES ON ALL COCKS INDICATE DIRECTION OF PASSAGE

TO PRODUCE INITIAL AIR PRESSURE ON MAIN GASOLINE TANK: TURN 3 WAY VALVE TO "PUMP" POSITION TO OPERATE HAND PUMP PUMP TO 3 LBS. PRESSURE.
TO RELIEVE PRESSURE ON MAIN TANK, TURN 3 WAY VALVE TO "RELEASE."
THE 3 WAY VALVE SHOULD BE TURNED TO "CLOSED" POSITION UNDER ALL OTHER CONDITIONS.

CHART NO. 424—Carburetion and Gasoline System.

(One of the Largest and Best Equipped Repair Shops in the U. S.)

CYLINDER
and
CRANK SHAFT GRINDING

Oversize Pistons, Rings and Wrist Pins made to fit. Skilled Mechanics and Special, Accurate Machinery.

GENERAL REPAIRING
and OVERHAULING

Send for Our Free Catalogue

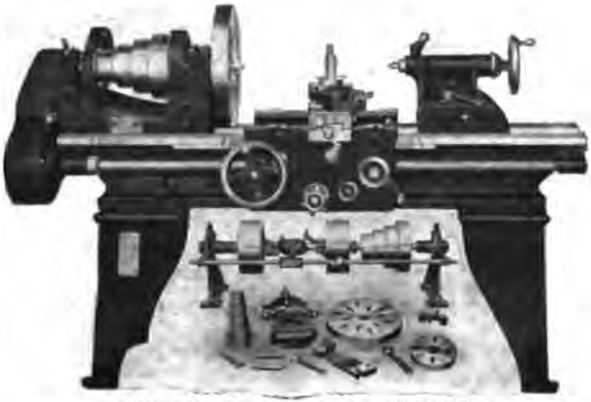
"Important Information"---Giving a lot of Useful Information and Prices Charged for Regrinding Cylinders, Crankshafts, Wrist Pins, Oversize Pistons, Scored Cylinder Repairs, etc.

Modern Auto Repair
and Reconstruction Company

4601 to 4613 Olive St. - - ST. LOUIS, MO.

CHAS. LESS, Pres. & Treas. V. LESS, Vice-Pres. A. R. SOLOMON, Secretary
WM. LOHSE, Supt. & Master Mechanic (Pioneer).

SOUTH BEND LATHES



16"x18" Lathe, Price $463.00.

Reasonable In Price.

20,000 South Bend Lathes are in use in manufacturing, and in general machine shop.

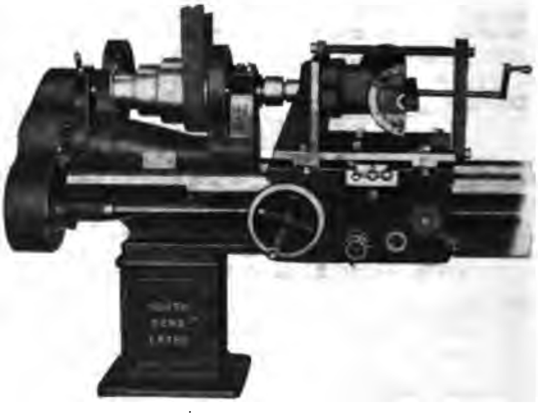
"How to Run a Lathe." An 80 page book postpaid to any address for ten cents, silver or stamps accepted.

South Bend Lathes are made in Six sizes with both straight and gap bed, from 13- to 24-inch swing.

South Bend
CYLINDER BORING ATTACHMENT
For Lathes

The illustration shows a cylinder of a Ford automobile engine being re-bored in lathe.

The correct way to re-bore cylinders for motorcycle, automobile, motor truck and tractor engines.



Free Lathe Catalog Mailed on Request.

Size of Lathe	No. 40—16"	No. 45—18"	No. 47—21"	No. 54—24"
Price of Boring Attachment	$75.00	$80.00	$90.00	$100.00
Weight of Boring Attachment	225 lbs.	275 lbs.	350 lbs.	400 lbs.

South Bend Lathe Works

424 E. Madison St. SOUTH BEND, IND.

Continental Radiator Stand.

Solder will not run uphill. Why waste half your time trying to get a radiator in just the right position that you can solder it when a thousand different positions are obtainable on a Continental Radiator Stand? The radiator is clamped securely to the Stand by rubber covered clamps that will not mar the highest finish, and the radiator can be turned in two directions, which allows any part to be brought to the top and the Stand being portable it is easily moved from place to place.

Continental Battery Stand.

When you work on heavy storage batteries, magnetos, starters or generators always place the work on a Continental Battery Stand. It can be revolved to any position and securely locked. Revolves on ball bearings, and the wooden top which is 10"x7" eliminates the danger of short circuits.

Continental Creeper.

Big Double Wheel Casters
Heavy Welded Frame
Rolls Easy
Will Not Break
Slats are Steel Bands
Big and Roomy
20 by 44 Inches
Malleable Casters
Well Padded Head Rest
Weight 50 lbs.

Continental Combination Jack and Industrial Truck.

Garage Jack.

A really good and efficient garage Jack that lifts the car entirely off the floor with one movement of the handle. It lifts at two points so that there is no danger of the car tipping off. It is instantly adjustable in height and requires but one movement to make this adjustment. One stroke of the handle raises the car two and one-half inches from the floor and being supported by two points there is no danger of the car tilting off the Jack.

Used as an Industrial Truck.

A Jack that serves a double purpose. It will be used about the shop as an industrial truck. Two tools at the cost of one. As an industrial-truck platforms may be made and oil barrels, etc., may be picked up and easily moved from place to place. A valuable tool that will repay its cost in a very short time.

Used as an Industrial Truck.

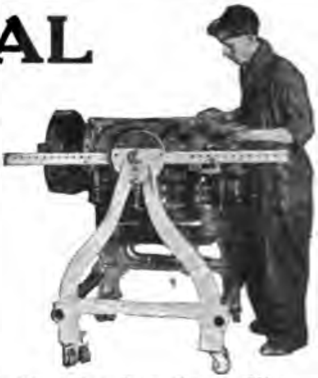
SEND FOR OUR COMPLETE CATALOG.

Continental Auto Parts Co.

306 W. Madison Street **Knightstown, Ind., U. S. A.**

CONTINENTAL

Shop Equipment.



Continental Motor Stand.

These stands are universal in operation. Adjustable in both height and width, and are equipped to handle all types of engines and unit power plants. They can be turned in any desired position and securely locked with a steel pin. Over twenty-five different locking positions enable you to bring the motor to any desired angle. Being portable the Stand readily adapts itself to progressive assembly. Ford attachments are furnished for handling the Ford engine. Every stand is complete—no extras to buy.

Continental Ford Engine Stand.

The patented principle of handling the Ford power plant used on Continental motor stands has proven so universally successful that we have produced a special stand for Ford engines only, and it is the only stand that handles the complete unit Ford power plant. It has the endorsement of thousands of satisfied users. It is the only stand you can get in which a complete power plant may be torn down and rebuilt without changing the engines' position in the stand. The cylinder block is clamped in the stand in such position that the crank case, transmission, crank shaft, fly wheel, magneto, connecting rods, pistons and cylinder head can be removed without re-arranging the Ford cylinder block in the Stand.

Continental Assembly and Welding Table.

This Welding Table will speed up your production and affect a great saving in gas. It is an every ready assistant that turns the work to the desired position and eliminates lost motion. A rotatable work table that saves time in every department from the machine shop to the finishing room. A necessity in production and commercial welding. The best work bench you ever saw.

Continental Axle Stand.

A third of your repair work is axle work. Speed up this department by using our Axle Stands. Handles any and all types of axles. **A real time saver and money maker. You cannot afford to be without it another day. The axle is clamped securely in position and the vise is adjustable to conform to the taper of any axle housing. The opposite support drops** out of position that semi-floating axles may be torn apart without releasing the axle from the vise.

Continental Assembly Table Bench Type.

A small revolving table for the work bench that will speed up all types of assembly work and cannot be excelled for lining up bearings and laying off all types of work.

WRITE TODAY—NOW—FOR

Free Illustrated Catalog on Dyke's Home Study Course

IT MAY MEAN A GREAT DEAL TO YOU IN THE FUTURE

LET US SHOW YOU pictures of shops and cars of students who are now engaged in business—who actually got their start through the Dyke Course—we will show you a HUNDRED or more of testimonials, if you write us.

Dyke's Correspondence School of Motoring,
Granite Building, St. Louis, Mo.

Gentlemen:—

Mail me your FREE printed matter explaining your Course of Automobile Engineering.

NAME ....

CITY ....

STREET .... STATE ....

NOTE—State if you now have the Encyclopedia and Models, or Encyclopedia alone.

(If you have Encyclopedia, be sure and state what Edition you have.)

A Few of the Many Testimonials.

First thought he could not learn by mail: Have just overhauled a car and had great success. People said a person could not learn by mail, and I will admit that it did have me guessing when I first read your ad, but I am now convinced. The working Models and the Charts, and particularly the **examinations,** make it easier to learn by your system than any other way.—E. A. Tucker, Charlotte, Mich.

Now running a repair shop: Mr. W. O. Johnson, Jr., of Spartansburg, Pa., is now operating a repair shop and supply store. He learned from Dyke's Course.

Learned more from course than in shop: To say that I am pleased with your Course is putting it mildly. Before buying it, I investigated five or six others, varying in price from $25 to $55. One of the concerns claimed they had models; but I remember seeing in your printed matter, that you were the inventor and patentee of the New Model Idea, so I insisted on their proving that they had models, which they could not do. The other schools seemed to be unwilling to give very much detail as to what their Course consisted of. **I am glad to say, that instead of misrepresenting your Course, I find it even better than you claim.** I have worked in two different garages, but have learned many things from your Course that I could not have learned in the shop. Your treatment of the ignition and other subjects is very clear indeed. Wilfred S. Baker, 129 State Street, Bristol, Rhode Island. Enrollment No. 6755.

More work than he can handle: Since taking your Course I have had all the work I can handle in overhauling engines and making adjustments.—O. A. Arnett, Woodland, Mich. Enrollment No. 8661.

I send you this letter to use to tell others: I do this because you have helped me and I want to now help you. After completing Course, I secured employment in a garage at a good salary. I have overhauled cars and have a good job the year round in the P. T. Legare Auto Garage.—George Gaudreau, 110 Massue Street, Quebec, Canada.

Leading Authorities of the Motoring World Recommend Dyke's Home Study Course.

Barney Oldfield, Chas. Duryea, Lord Montagu of England and many others. Write us for our catalog and read what they say.

Some Firsts in America—By A. L. Dyke.

The first practical automobile book published in America was published by A. L. Dyke. The small book, illustration of which is shown, was originally prepared in 1899 and 1900. It was revised in 1903.

In the issue of Motor Age, Oct. 29, 1903 a part of the article reads; "The A. L. Dyke Co., published the first practical automobile work intended solely for the automobile user."

Illustration of the first practical automobile book published in America.

The first automobile supply business in America was originated by A. L. Dyke. In issue of Motor Vehicle Review, published in Cleveland, Ohio, 1900, now "The Automobile" of New York, part of the article reads: "Mr. Dyke originally started in the automobile supply business, the first in America in 1897." The Automobile Review of Chicago, issue of April 1900 states; "Very early in the industry Mr. Dyke saw there would be a demand for Auto Supplies, parts, etc. and organized and incorporated The St. Louis Automobile and Supply Co."

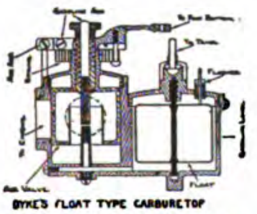


Illustration of the original drawing of the first constant level type carburetor placed on the American market.

The first float feed carburetor manufactured and placed on the American market was advertised and marketed by A. L. Dyke in 1900. At that time the few automobile manufacturers **were using** mixing valves.

NOTE—We advise one to take a Practical Course if possible—at a good school—but don't for a moment you are going to learn without studying—go to a school where books are used.

Dyke's
Home Study Course of Automobile Engineering—$18.

If you have Dyke's Auto Encyclopedia or the Models, or both, a reduction will be made on the Course. Be sure and state what Edition of the Encyclopedia you have.

For the benefit of those who wish to learn the business of **repairing and operating automobiles** and gasoline engines, we have prepared a **Complete Home Study Course.** It is sent to the student all complete in a special box, and which

One page of the Examination Questions.

Consists of

50—**Instructions**, with thorough and complete examination questions.

1—**Working model** of the 4 cylinder engine.

1—**Working model** of the 6 cylinder engine.

1—**Set of charts** showing the application and relation of the clutch and transmission to the engine—also magneto, coil, and battery ignition and electric starter and how the generator is mounted, etc.

1—**Progressive Chart Manikin,** showing how a car is constructed from the ground up.

A Diploma is awarded when you complete the Course.

Our time in correcting your answers to the examination questions, alone is worth the price we ask for the Course.

The Examination Questions.

There are questions to each of the instructions to which, the student (taking his own time), is required to write the answers. The answers are written on paper and then forwarded to our examination department for the proper grading and answering of questions the student may ask relative to the Course.

The student is graded and a handsome Diploma is awarded when he completes the course. (One year's time is allowed to complete the course. It is possible however, to complete the course in three or four months.)

Many students who have taken our course, are now actively engaged in the auto repair business, also as chauffeurs and other branches of the industry, and are earning good salaries and making money.

Why You Ought to Take the Course.

(1) **Because—the examinations will bring out many pointers and subjects you would never think of by reading a book. You will gain information worth hundreds of dollars to you.**

(2) **Because**—the examination questions start you at the beginning of a subject—and in a progressive manner advances you step by step, from the first principles—to the more complicated subjects—as you should progress.

(3) **Because**—merely writing down the answers to the questions on paper—would be a good training—because you would be memorizing the answer as you write it down.

(4) **Because**—you will gain a clear understanding of subjects which are not now clear to you—which will be worth considerable to you in time to come.

(5) **Because**—the study consists of two general and distinct divisions; the study of interesting instructions and actual practice on the models—which are referred to from the text.

(6) **Because**—technical language is avoid- [illegible] roughout the Course, so that any one who can read and write "everyday" English can learn. It progresses in easy, natural steps from one part to another till finally you are taught the operation of this wonderful power plant as a whole, then how to locate, remedy and repair trouble—in a scientific manner.

(7) **Because**—the price is extremely low, compared to the advantages gained and compared to the high prices charged by others. When you consider the fact that other schools offer courses ranging from $25 to $75, imagine if you will, how and where you could place $18 to better advantage. Here we offer you the most complete course in the world.

(8) **Because**—you will not only learn all about automobiles, but you will understand truck, tractor, motor boat and airplane engines—which is bound to be of great value to you.

(9) **Because—the examination questions will give you a training you could not get by reading a book—think it over—in the meantime send for our free catalog on the Course.**

e one to take a Practical Course if possible—at a good school—but don't think for a going to learn without studying—go to a school where books are used.